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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

Assessment of Mediterranean Stocks Part I

31 MAY - 4 JUNE 2010, HERAKLION, CRETE, GREECE

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The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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31 May - 4 June 2010, Heraklion, Crete, GREECE

STECF UNDERTOOK THE REVIEW DURING THE PLENARY MEETING

HELD IN BRUSSEL 8-12 NOVEMBER 2010

1. BACKGROUND

The European Community is expected to establish long-term management plans (LTMP) for relevant Mediterranean demersal and small pelagic fisheries, based on the precautionary approach and adaptive management in taking measures designed to protect and conserve aquatic living resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine ecosystems (target and non target species and habitat) following the Marine Strategy (Directive 2008/56/CE) and the Green Paper on the Reform of the CFP (COM(2009)163 final).

STECF can play an important role in focusing greater contributions for European scientists towards stocks and fisheries assessment, in identifying a common scientific framework regarding specific analyses to advise on Community plans, to be then channeled into or completed by the GFCM working groups.

STECF was requested at its 2007 November plenary session to set up an operational work programme for 2008, beginning in the 1st quarter of 2008, with a view to update the status of the main demersal stocks and evaluate the exploitation levels with respect to their biological and economic production potentials and the sustainability of the stock by using both trawl surveys and commercial catch/landing data as collected through the Community Data Collection regulation N° 1543/2000 as well as other scientific information collected at national level.

The work of STECF's subgroup on Mediterranean Sea and Black Sea continued in 2009 with the SGMED-09-01 meeting on advice reviews for 2009 for sprat and turbot in the Black Sea in Ranco, Italy, 23-27 March 2009, SGMED-09-02 part I in Villasimius, Sardinia, Italy, 8-12 June 2009 on the historic assessments and management advice regarding historic status of Mediterranean stocks, and with SGMED-09-03 part II in Barza d' Ispra, Italy, 14-18 December 2009 dealing mainly with short and medium term forecasts of stock size and landings of Mediterranean stocks under different management options. In 2010, SGMED-10-01 held a dedicated workshop in Barcelona, Spain, 22-26 March 2010. The present report of SGMED-10-02 contains updates and new assessments of relevant stock parameters and management reference points in the format elaborated in 2008. In December 2010 SGMED-10-03 will again complement such historic and recent trends with short and medium term forecasts of stock sizes and landings under various management scenarios.

2. TERMS OF REFERENCE

STECF is requested to

a) update and assess historic and recent stock parameters for the longest time series possible of the species listed below and parameters of their fisheries (by fleets) by all relevant individual GSAs in the Mediterranean Sea or combined GSAs where appropriate. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010. Data collected outside the DCF and/or delivered to the meeting by non-EU scientists shall be used as well and merged with DCF data whenever necessary.

•Sardine (*Sardina pilchardus*)
•Anchovy (*Engraulis encrasicolus*)
•European hake (*Merluccius merluccius*)
•Common sole (*Solea solea*)
•Red mullet (*Mullus barbatus*)
•Deep-water rose shrimp (*Parapenaeus longirostris*)
•Red shrimp (*Aristeus antennatus*)
•Giant red shrimp (*Aristaeomorpha foliacea*)
•Norway lobster (*Nephrops norvegicus*)

b) assess historic and recent stock parameters for the longest time series possible of the species listed below and parameters of their fisheries (by fleets) by all relevant individual GSAs in the Mediterranean Sea or combined GSAs where appropriate. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010. Data collected outside the DCF and/or delivered to the meeting by non-EU scientists shall be used as well and merged with DCF data whenever necessary.
•Picarel (*Spicara smaris*)
•Other species of the Tables 1 and 2 of the official Mediterranean DCF data call issued on 29 April 2010 (see annex) with particular attention to: Common Pandora (*Pagellus erythrinus*), striped red mullet (*Mullus surmuletus*), bogue (*Boops boops*), sea bass (*Dicentrarchus labrax*), blue whiting (*Micromesistius poutassou*), gilthead seabream (*Sparus aurata*), Blackspot seabream (*Pagellus bogaraveo*), Poor cod (*Trisopterus minutus*), Sargo breams (*Diplodus spp.*), mackerel (*Scomber spp.*), spottail mantis squillid (*Squilla mantis*)

c) review of assessments of historic and recent stock parameters of demersal and small pelagic species listed under a) and b) and assessments of their fisheries in the Mediterranean Sea as conducted by other scientific frameworks including also national framework of non-EU countries.

d) assess, propose and review biological fisheries management reference points of exploitation and stock size related to high yields and low risk of fishery collapse in long term of each of the stocks listed under a) and b) and assessed by SGMED or other scientific frameworks. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010 while also taking into account the outcomes of previous data calls.

e) summarize and concisely describe in a separate chapter all data quality deficiencies of relevance for the assessment of stocks and fisheries resulting from the official Mediterranean DCF data call issued on 29 April 2010 while also taking into account the outcomes of previous data calls. Such description is to be forwarded to STECF/SGRN for its review and reconciliation of national programs.

f) advise on the recent status of exploitation and stock size of the species listed under a) and b) in relation to the biological fisheries management reference points as identified under d).

g) test the empirical biologic indicators and methodologies for their calculation recommended by SGMED-10-01 to be applied for stock assessment in data poor situations. Such tests should be run using the examples of data rich stocks. SGMED is requested to comment on the applicability of the results obtained from the empirical indicators for scientifically sound fisheries management advice.

h) continue the formulation of the program R-scripts and to test them to evaluate MEDITS and other CPUE or abundance survey results as initialized during SGMED-10-01 taking also into account the proposed draft terms of reference by SGMED-10-01. As a first priority, the survey evaluation should allow assessments of trends in stock specific abundance and biomass trends, also age based, not only for the total stock but also separately for the juvenile and adult components. As a second priority, standardization between independent time series of surveys with respective parameters of correlation, bias and precision shall be realized.

i) note that the last meeting of STECF/SGMED-10-03 in 2010 will focus on short and medium term projections of stock size and catches as well as bio-economic modeling as successfully conducted in 2009.

j) propose and test a scorecard for stock and fisheries assessment data quality. The scorecard should work as a factual summary and easily contribute to the interpretation of the assessment quality with regard to data availability. SGMED should consider how the information can be implemented in its stock summary sheets to avoid work duplication.

Table 1: Additional species as included in the data collection regulations.

Species common name Species scientific name FAO CODE
1. Bogue *Boops boops* BOG
2. Common dolphinfish *Coryphaena hippurus* DOL
3. Sea bass *Dicentrarchus labrax* BSS
4. Grey gurnard *Eutrigla gurnardus* GUG
5. Black-bellied angler *Lophius budegassa* ANK
6. Anglerfish *Lophius piscatorius* MON
7. Blue whiting *Micromesistius poutassou* WHB
8. Grey mullets (*Mugilidae*) Mugilidae MUL
9. Common Pandora *Pagellus erythrinus* PAC
10. Caramote prawn *Penaeus kerathurus* TGS
11. Mackerel *Scomber spp.* MAZ
12. Common sole *Solea solea* (=*Solea vulgaris*) SOL
13. Gilthead seabream *Sparus aurata* SBG
14. Spottail mantis squillids *Squilla mantis* MTS
15. Mediterranean horse mackerel *Trachurus mediterraneus* HMM
16. Horse mackerel *Trachurus trachurus* HOM
17. Tub gurnard *Trigla lucerna* (= *Chelidonichthys lucerna*) GUU

Table 2: Additional species not included in the data collection regulations .

Species common name Species scientific name FAO CODE
1. Sargo breams *Diplodus spp.* SRG
2. Axillary seabream *Pagellus acarne* SBA
3. Blackspot seabream *Pagellus bogaraveo* SBR
4. Greater forkbeard *Phycis blennoides* GFB
5. Poor cod *Trisopterus minutus* POD

3. STECF OBSERVATIONS

STECF notes that during the STECF-SGMED-10-02, with exception of **ToRs g) (**requesting tests of empirical biologic indicators) and **ToR j) (**requesting tests of data availability score cards), all other TORs were successfully addressed. In particular, the STECF-SGMED-10-02 report dealt with the assessment of historic and recent trends in stock parameters (stock size, recruitment and exploitation) and relevant scientific fisheries management advice. SGMED-10-02 presents 69 stock assessment approaches with relevant data for European hake (*Merluccius merluccius*, 14 stocks), red mullet (*Mullus barbatus*, 15 stocks), striped mullet (*Mullus surmuletus*, 2 stocks), common Pandora (*Pagellus erythrinus*, 1 stock), common sole (*Solea solea*, 1 stock), anchovy (*Engraulis encrasicolus*, 6 stocks), sardine (*Sardina pilchardus*, 5 stocks), pink shrimp (*Parapenaeus longirostris*, 10 stocks), blue and red shrimp (*Aristeus antennatus*, 4 stocks), giant red shrimp (*Aristaeomorpha foliacea*, 4 stocks), and Norway lobster (*Nephrops norvegicus*, 7 stocks). Such stock assessment approaches by the STECF-SGMED-10-02 WG cover new stocks and new species (striped mullet and common pandora) as compared with last year's (2009) deliveries (STECF-SGMED-09-02).

The following table summarizes the findings from the STECF-SGMED-10-02 WG report.

species	assessment	estimated	status	status	status
	approaches	exploitation rates	overfished	sustainably fished	unknown
European hake	14	8	8	0	0
red mullet	15	7	7	0	0
striped mullet	2	1	1	0	0
common pandora	1	1	1	0	0
common sole	1	1	1	0	0
anchovy	6	6	5	1	0
sardine	5	5	2	3	0
pink shrimp	10	5	4	0	1
blue and red shrimp	4	1	0	0	1
giant red shrimp	4	1	1	0	0
Norway lobster	7	2	2	0	0
sum	69	38	32	4	2

For 38 of the 69 stock assessment approaches resulted in analytical assessments of exploitation rates or coefficients of exploitation rates (fishing mortality), while for 36 stocks fisheries management advice consistent with high long term yields conditional of proposed reference points could be provided. The status of 2 crustacean stocks remains unknown. Overall, the recent (in 2008 or 2009) status of 32 out of 36 stocks was assessed as overfished (89%), while only 4 stocks were considered sustainably exploited consistent with high long term yields. All demersal fish stocks (100% of 18 stocks) were found overexploited. Among the 9 crustacean stocks assessed 7 were overexploited (78%) with 2 stocks of unknown status. The highest rate of sustainably exploited stocks (36%) was found among the small pelagics, where 7 out of 11 stocks (64% of the total) were classified as overexploited. In some cases (e.g. red mullet in GSA06) the status of overexploitation was already detected in the analyses conducted more than ten years ago confirming that some Mediterranean European fish stocks have been overfished for decades.

The STECF-SGMED-10-02 WG considered that the scientific management advice for fisheries exploiting the assessed demersal fish and crustacean stocks focuses on the need to implement multi-annual management plans in the near future. Those plans should aim to reduce fishing mortality, through fishing effort reductions, towards the proposed limit management reference points consistent with high long term yields. The STECF_SGMED-10-02 WG noted that it is unlikely that conflicts between multispecies fisheries will arise during the initial phase of such management plans as the great majority of the assessed demersal stocks are overfished.

The STECF-SGMED-10-02 WG considered that the scientific management advice for fisheries exploiting the assessed stocks of small pelagic focuses on the need focuses on the need to implement multi-annual management plans in the near future. Those plans should aim to keep fishing mortality at or below the proposed limit management reference points consistent with high long term yields or to reduce fishing mortality towards them. STECF notes that the management of fisheries targeting stocks of small pelagics through effort management alone runs the risk of not achieving the desired objectives. The reason for this is: Fleets exploiting small pelagic species in the Mediterranean have the ability to target more than one stock and a restriction on overall fleet effort does not ensure a reduction in effort on the stock of concern. For example a fleet currently exploiting stock A, which is more valuable than stock B, could choose to direct all of its effort to stock A if the effort is restricted since the revenue gained would be greater. Thus, STECF agrees with STECF-SGMED 10-02 that landing restrictions may be a more appropriate management tool to control the exploitation rate on small pelagics in the Mediterranean than effort restrictions alone. Taking into account the above arguments, STECF **recommends** that consideration be given to introduce additional measures including restrictions on landings as a more effective means to achieve desired exploitation rates on small pelagic species in the Mediterranean. The species of concern are primarily anchovy and sardine.

STECF emphasizes that to assess the effectiveness of multi-annual management plans implies that evaluations are undertaken at appropriately-prescribed intervals and that the plans are adapted in the light of the results of the evaluations. The plans need to be supported by effective control and enforcement measures together with collection of fisheries-related data. STECF notes that not all Member States have fully implemented the Data Collection Regulation and notes that full implementation of the provisions of the data collection regulation is a prerequisite to effective scientific monitoring and management of the stocks and fisheries.

The STECF-SGMED-10-02 WG also reviewed the stock assessments of anchovy and sardine in GSA 17 carried out within the framework of FAO-AdriaMed Project and presented at GFCM-SAC-SCSA meeting in 2009 (Malaga, 2009). Results were reviewed and compared with previous assessments carried out by the 2009 STECF-SGMED 09-02 WG. Significant improvements in the new assessments in relation to previous assessments were noted. However, detailed information on input data as number and weight at age by each fleet and country and parameter diagnostics of the assessments are missing in the report. However, in absence of detailed information on input data as number and weight at age by each fleet and country, diagnostics of the assessments models and the fact that the use of growth parameters are not in line with previous STECF-SGMED WG recommendations, STECF is not in the position to endorse the results of these assessments of anchovy and sardine in GSA 17.

The STECF-SGMED-10-02 WG reports that inconsistent information as well as late and lack of data submissions again significantly hampered the accomplishment of its tasks. Major drawbacks were missing fisheries data for 2009 from Italy, Greece and Cyprus, as well as a late submission of data from Malta, which impeded updates and assessments of most recent parameters of many exploited stocks in the relevant GSAs.

The STECF-SGMED-10-02 report recommends that the data sets for conducting stock assessment need to be available well in advance (4 weeks) before the beginning of the relevant assessment meetings in order to allow JRC to process, evaluate and prepare the data for the assessment working groups. The report also recommends that no data should be accepted after the deadline for submission and that erroneous data should be interpreted as being not submitted. Furthermore, the WG notes that any progress in data submissions in terms of compliance with uploading procedures and data consistencies will compromise the necessary preparations for future working groups. In addition and in accordance with the provisions of the DCF to allow appropriate data preparation by Member States, the STECF-SGMED recommends future data calls should be issued at least 2 months in advance of assessment meetings.

STECF notes that the STECF-SGMED-10-02 WG has continued to develop and test specific R scripts to evaluate MEDITS and other CPUE or abundance surveys and has recommended that a dedicated workshop be established to undertake the following:

- perform an in depth effort to standardize MEDITS abundance data for main target and priority species using the R scripts,
- further test if the age slicing function (conversion of length structured data into age structured data) developed within the R scripts is usable for different species as shrimps,
- finalize and test the scriptsa for the standardization of the abundance at age indices and
- perform comparative SURBA assessments with numbers at age standardized using appropriate models and those empirically rised to the surface or time units.

The STECF-SGMED-10-02 report notes that bio-economic modelling, deterministic short and medium term predictions of stock size and catches (landings) under various management options and the relevant scientific advice will be conducted during the STECF-SGMED-10-03 WG (13-17 December 2010). However, the STECF-SGMED-10-02 report stresses that the lack of 2009 fisheries data will impede such short term forecasts for many stocks and fisheries in GSAs bordering the Italian, Greek and Cyprian coasts.

4. STECF RECOMMENDATIONS AND CONCLUSIONS

STECF endorses the STECF-SGMED-10-02 WG report and agrees with the recommendations listed in the report.

STECF agrees that there is the need to implement multi-annual management plans in the near future for Mediterranean demersal fisheries. Those plans should aim to reduce fishing mortality, through fishing effort reductions, towards the proposed limit management reference points consistent with high long term yields.

STECF agrees with STECF-SGMED 10-02 recommendation that landing restriction may be a more appropriate management tool to control the exploitation rate on small pelagics in the Mediterranean than effort restrictions alone. Taking into account the above arguments, STECF **recommends** that consideration be given to introducing addition measures including landing restrictions as a more effective means to achieve desired exploitation rates on small pelagic species in the Mediterranean. The species of concern are primarily anchovy and sardine.

STECF **recommends** that the data sets for conducting stock assessment need to be made available well in advance (4 weeks) before the beginning of the relevant assessment meetings in order to allow JRC to process, evaluate and prepare the data for the STECF-SGMED assessment working groups.

STECF **recommends** that no data should be accepted after the deadline for submission and that erroneous data should be interpreted as being not submitted.

STECF **recommends** that future data calls to be issued at least 2 months in advance of STECF-SGMED assessment WG meetings.

STECF **recommends** that a dedicated workshop be established to continue to develop and test specific R scripts to evaluate MEDITS and other CPUE or abundance surveys.

SGMED-10-02 WORKING GROUP REPORT: ASSESSMENTS OF MEDITERRANEAN STOCKS PART I

31 May - 4 June 2010, Heraklion, Crete, GREECE

1. Executive Summary and Recommendations

With the aim of establishing the scientific evidence required to support development of long-term management plans for selected fisheries in the Mediterranean, consistent with the objectives of the Common Fisheries Policy, and to strengthen the Community's scientific input to the work of GFCM, the Commission made a number of requests to STECF. The Terms of Reference (TORs) for SGMED-10-02 were extensive and are listed in section 2.1.

In accordance with the **ToRs a, b, d and f**, this SGMED-10-02 report deals with assessment of historic and recent trends in stock parameters (stock size, recruitment and exploitation) and relevant scientific fisheries management advice. In section 5 SGMED-10-02 presents 69 stock assessment approaches with relevant data for European hake (*Merluccius merluccius*, 14 stocks), red mullet (*Mullus barbatus*, 15 stocks), striped mullet (*Mullus surmuletus*, 2 stocks), common Pandora (*Pagellus erythrinus*, 1 stock), common sole (*Solea solea*, 1 stock), anchovy (*Engraulis encrasicolus*, 6 stocks), sardine (*Sardina pilchardus*, 5 stocks), pink shrimp (*Parapenaeus longirostris*, 10 stocks), blue and red shrimp (*Aristeus antennatus*, 4 stocks), giant red shrimp (*Aristaeomorpha foliacea*, 4 stocks), and Norway lobster (*Nephrops norvegicus*, 7 stocks). Such stock assessment approaches by SGMED-10-02 cover new stocks and new species (striped mullet and common pandora) as compared with last year's (2009) deliveries (SGMED-09-02).

The analytical assessments, proposed management reference points and scientific advices are summarized in the summary sheets in section 4 of this report. Fisheries and stock specific recommendations from SGMED-10-02 can be found in section 4. The following table summarizes the findings. 38 of the 69 stock assessment approaches resulted in analytical assessments of exploitation rates or coefficients of exploitation rates (fishing mortality), while for 36 stocks fisheries management advice consistent with high long term yields conditional of proposed reference points could be provided. The status of 2 crustacean stocks remain unknown. Overall, the recent (in 2008 or 2009) status of 32 out of 36 stocks was assessed as overfished (89%), while only 4 stocks were considered sustainably exploited consistent with high long term yields. All demersal fish stocks (100% of 18 stocks) were found overexploited. Among the 9 crustacean stocks assessed 7 were overexploited (78%) with 2 stocks of unknown status. The highest rate of sustainably exploited stocks (36%) was found among the small pelagics, where 7 out of 11 stocks (64% of the total) were classified as overexploited. In addition, two of the stocks analyzed (anchovy and sardine in GSA 16) showed very low levels of biomass in recent years (see 4.24 and 5.49). In some cases (e.g. red mullet in GSA06) the status of overexploitation was already detected in the analyses conducted more than ten years ago confirming that some Mediterranean European fish stocks have been overfished for decades.

Overview table on numbers of stock assessment approaches and exploitation status by species.

species	assessment approaches	estimated exploitation rates	status overfished	status sustainably fished	status unknown
European hake	14	8	8	0	0
red mullet	15	7	7	0	0
striped mullet	2	1	1	0	0
common pandora	1	1	1	0	0
common sole	1	1	1	0	0
anchovy	6	6	5	1	0
sardine	5	5	2	3	0
pink shrimp	10	5	4	0	1
blue and red shrimp	4	1	0	0	1
giant red shrimp	4	1	1	0	0
Norway lobster	7	2	2	0	0
sum	69	38	32	4	2

The scientific management advice for fisheries exploiting the assessed demersal fish and crustacean stocks focuses on the need for implementation of consistent multi-annual management plans to reduce fishing mortality through fishing effort reductions towards the proposed limit management reference points consistent with high long term yields. SGMED-10-02 notes that it is unlikely that conflicts between multi-species fisheries will arise during the initial phase of such management plans as the great majority of the assessed demersal stocks are overfished.

The scientific management advice for fisheries exploiting the assessed stocks of small pelagic focuses on the need for implementation of consistent multi-annual management plans to keep fishing mortality at or below the proposed limit management reference points consistent with high long term yields or to reduce fishing mortality towards them. SGMED-10-02 notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. Such landing restrictions would solve potential multi-species conflicts in the relevant fisheries for small pelagic.

In accordance with **ToR c)** SGMED-10-02 reviewed the stock assessments of anchovy and sardine in GSA 17 carried out within the framework of FAO-AdriaMed Project and presented at GFCM-SAC-SCSA meeting in 2009 (Malaga, 2009). Results were reviewed and compared with SGMED's previous assessments in 2009 (SGMED-09-02). Significant improvements in the new assessments in relation to previous assessments were noted by SGMED. However, detailed information on input data as number and weight at age by each fleet and country and parameter diagnostics of the assessments are missing in the report. However, in absence of detailed information on input data as number and weight at age by each fleet and country, diagnostics of the assessments models and the fact that the use of growth parameters are not in line with previous SGMED recommendations, SGMED-10-02 is not in the position to endorse the results of these assessments of anchovy and sardine in GSA 17. Further recommendations relevant to future assessments and their presentations can be found in section 3.1.

As a response to **ToR e)** SGMED-10-02 notes that the presented assessments are largely based on data obtained through the DCR (until 2008) and DCF (2009) with regard to the official call issued on 29 April 2010 by DG Mare for fisheries and scientific survey data (published on the STECF homepage https://datacollection.jrc.ec.europa.eu/), also covering data collected during national programmes or projects co-funded by the EU-Commission. A summary and recommendations regarding national data submissions and data quality is provided in section 3.3 of this report. SGMED was often unable to verify the origin or quality of the data used in the assessment but will continue its effort to validate the data through expert knowledge and transparent presentation of the data.

Inconsistent, late and lack of data submissions again significantly hampered the accomplishment of SGMED's tasks. Major drawbacks were missing fisheries data for 2009 from Italy, Greece and Cyprus, as well as a late submission of data from Malta, which impeded updates and assessments of most recent parameters of many exploited stocks in the relevant GSAs. Such cases are clearly identified in the following assessment sections which include other data updates as available and appropriate in order to facilitate and promote future assessments. SGMED-10-02 acknowledges the various contributions of Spanish and French experts which resulted in major improvements of the relevant stock assessments and derived scientific advice.

SGMED-10-02 notes that the data sets need to be available well in advance (4 weeks) before the beginning of the relevant assessment meetings in order to allow JRC to process, evaluate and prepare the data for the assessment working groups. SGMED-10-02 recommends that no data should be accepted after the deadline for submission and that erroneous data should be interpreted as being not submitted. SGMED-10-02 notes that any progress in data submissions in terms of compliance with uploading procedures and data consistencies will disburden the necessary preparations for the STECF working groups. In addition and in accordance with the provisions of the DCF to allow appropriate data preparation by Member States, SGMED recommends future data calls to be issued at least 2 months in advance of assessment meetings.

Due to time and human resources constraints, SGMED-10-02 was unable to deal with **ToRs g)** requesting tests of empirical biologic indicators, and **ToR j)** requesting tests of data availability score cards. SGMED-10-02 refers to the recommendations of STECF during its spring plenary in 2010 based on the findings documented in the report of SGMED-10-01.

SGMED-10-02 continued to develop and test specific software to evaluate MEDITS and other CPUE or abundance surveys (**ToR h**). As anticipated, the errors in the current MEDITS data base although improved from the version available for SGMED 10-01, can either make the R script crash or can return misleading trends. The R script for cpue standardization performs well, unless there are errors that should not be in the database. An in deep understanding of the suitability and performance of selected models and factors to be used for species and GSAs is also needed. SGMED-10-02 notes that the program code for the length slicing routine in R was updated to improve the interface with the database access script. It was also modified to make the code more robust to user and data errors. The slicing methodology remained the same as before and is based on calculating the proportion of the length groups that falls within each age group, given the von Bertalanffy growth parameters L_{inf}, K and t_0.

SGMED-10-02 recommends that

- if fast and routine use of MEDITS data stored in the SGMED database is a foreseeable goal, a reliable and error free database should be made available for stock assessment.
- a dedicated workshop be established to
    1. perform an in depth effort to standardize MEDITS cpues for main target and priority species using the R script.
    2. further test the age slicing function (conversion of length structured data into age structured data) developed within the R scripts is advisable with different species like shrimps.
    3. finalize and test the outstanding standardization of the CPUE of the abundance indices at age.
    4. perform comparative SURBA assessments with numbers at age standardized using appropriate models and empirically rised to the surface or time units.

In accordance with **ToR i)** SGMED-10-02 planned to undertake deterministic short and medium term predictions of stock size and catches (landings) under various management options as well as relevant scientific advice to be delivered through the forthcoming SGMED-10-03 meeting (13-17 December 2010). Such quantitative considerations will consider the recent mesh size changes as defined in the Corrigendum to Council Regulation (EC) No 1967/2006 of 21 December 2006. SGMED-10-02 stresses that the lack of 2009 fisheries data will impede such short term forecasts for many stocks and fisheries in GSAs bordering the Italian, Greek and Cyprian coasts.

SGMED-10-02 notes that bio-economic modeling was deferred to be conducted during SGMED-10-03 (13-17 December 2010).

2. INTRODUCTION

The European Community is expected to establish long-term management plans (LTMP) for relevant Mediterranean demersal and small pelagic fisheries, based on the precautionary approach and adaptive management in taking measures designed to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine ecosystems (target and non-target species and habitats) following the Marine Strategy (Directive 2008/56/CE) and the Green Paper on the Reform of the CFP (COM(2009)163 final).

STECF can play an important role in focusing greater contributions for European scientists towards stocks and fisheries assessment, in identifying a common scientific framework regarding specific analyses to advise on Community plans, to be then channeled into or completed by the GFCM working groups.

STECF was requested at its 2007 November plenary session to set up an operational work programme for 2008, beginning in the 1st quarter of 2008, with a view to update the status of the main demersal stocks and evaluate the exploitation levels with respect to their biological and economic production potentials and the sustainability of the stock by using both trawl surveys and commercial catch/landing data as collected through the Community Data Collection Regulation N° 1543/2000 and the Data Collection Framework Regulation N° 199/2008 as well as other scientific information collected at national level.

To address the requests, the STECF Subgroup on the Mediterranean (SGMED-10-02) for demersal and small pelagic stocks met in 31 May - 4 June 2010, Heraklion, Crete, Greece. The meeting was opened at 9:00 am on the 31st May, and closed at 17:00 on the 4th June The meeting built upon the work performed during SGMED meetings conducted during 2008 and 2009 to pursue the Commission's requests. Overall, a total of 27 scientists from several research centers and universities belonging to nine countries attended to the SGMED-10-02 meeting.

SGMED presents its reviews of stocks assessed under other scientific frameworks (ToR c), (anchovy and sardine in GSA 17) in section 3.1. SGMED-10-02 generic responses to the specific questions of ToR e) and h), i.e. data quality and specific software development are given in the following section 3. In accordance with the ToR related to stock assessments and scientific advice, the main report is structured into two parts. The first part (section 4) consists of the stock specific (species and area) summary sheets of the various assessments concluded by SGMED-10-02 providing estimated stock status and scientific advice. The second part (section 5) documents the various assessments in detail with the basic data (where available), methods applied and results, even in cases where stock status could not be assessed and no scientific advice could be formulated.

2.1. Terms of Reference for SGMED-10-02

The overall terms of reference for the SGMED meetings are listed in Appendix 1. The specific terms of reference for SGMED-10-02 were:

During its meeting in Crete (31/5-4/6/2010), Greece, STECF/SGMED-10-02 is requested to

a) update and assess historic and recent stock parameters for the longest time series possible of the species listed below and parameters of their fisheries (by fleets) by all relevant individual GSAs in the Mediterranean Sea or combined GSAs where appropriate. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010. Data collected outside the DCF and/or delivered to the meeting by non-EU scientists shall be used as well and merged with DCF data whenever necessary.
•Sardine (*Sardina pilchardus*)
•Anchovy (*Engraulis encrasicolus*)

•European hake (*Merluccius merluccius*)
•Common sole (*Solea solea*)
•Red mullet (*Mullus barbatus*)
•Deep-water rose shrimp (*Parapenaeus longirostris*)
•Red shrimp (*Aristeus antennatus*)
•Giant red shrimp (*Aristaeomorpha foliacea*)
•Norway lobster (*Nephrops norvegicus*)

b) assess historic and recent stock parameters for the longest time series possible of the species listed below and parameters of their fisheries (by fleets) by all relevant individual GSAs in the Mediterranean Sea or combined GSAs where appropriate. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010. Data collected outside the DCF and/or delivered to the meeting by non-EU scientists shall be used as well and merged with DCF data whenever necessary.
•Picarel (*Spicara smaris*)
•Other species of the Tables 1 and 2 of the official Mediterranean DCF data call issued on 29 April 2010 (see annex) with particular attention to: Common Pandora (*Pagellus erythrinus*), striped red mullet (*Mullus surmuletus*), bogue (*Boops boops*), sea bass (*Dicentrarchus labrax*), blue whiting (*Micromesistius poutassou*), gilthead seabream (*Sparus aurata*), Blackspot seabream (*Pagellus bogaraveo*), Poor cod (*Trisopterus minutus*), Sargo breams (*Diplodus spp.*), mackerel (*Scomber spp.*), spottail mantis squillid (*Squilla mantis*)

c) review of assessments of historic and recent stock parameters of demersal and small pelagic species listed under a) and b) and assessments of their fisheries in the Mediterranean Sea as conducted by other scientific frameworks including also national framework of non-EU countries.

d) assess, propose and review biological fisheries management reference points of exploitation and stock size related to high yields and low risk of fishery collapse in long term of each of the stocks listed under a) and b) and assessed by SGMED or other scientific frameworks. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on 29 April 2010 while also taking into account the outcomes of previous data calls.

e) summarize and concisely describe in a separate chapter all data quality deficiencies of relevance for the assessment of stocks and fisheries resulting from the official Mediterranean DCF data call issued on 29 April 2010 while also taking into account the outcomes of previous data calls. Such description is to be forwarded to STECF/SGRN for its review and reconciliation of national programs.

f) advise on the recent status of exploitation and stock size of the species listed under a) and b) in relation to the biological fisheries management reference points as identified under d).

g) test the empirical biologic indicators and methodologies for their calculation recommended by SGMED-10-01 to be applied for stock assessment in data poor situations. Such tests should be run using the examples of data rich stocks. SGMED is requested to comment on the applicability of the results obtained from the empirical indicators for scientifically sound fisheries management advice.

h) continue the formulation of the program R-scripts and to test them to evaluate MEDITS and other CPUE or abundance survey results as initialized during SGMED-10-01 taking also into account the proposed draft terms of reference by SGMED-10-01. As a first priority, the survey evaluation should allow assessments of trends in stock specific abundance and biomass trends, also age based, not only for the total stock but also separately for the juvenile and adult components. As a second priority, standardization between independent time series of surveys with respective parameters of correlation, bias and precision shall be realized.

i) note that the last meeting of STECF/SGMED-10-03 in 2010 will focus on short and medium term projections of stock size and catches as well as bio-economic modeling as successfully conducted in 2009.

j) propose and test a scorecard for stock and fisheries assessment data quality. The scorecard should work as a factual summary and easily contribute to the interpretation of the assessment quality with regard to data availability. SGMED should consider how the information can be implemented in its stock summary sheets to avoid work duplication.

Table 1: Additional species as included in the data collection regulations.

Species common name Species scientific name FAO CODE
1. Bogue *Boops boops* BOG
2. Common dolphinfish *Coryphaena hippurus* DOL
3. Sea bass *Dicentrarchus labrax* BSS
4. Grey gurnard *Eutrigla gurnardus* GUG
5. Black-bellied angler *Lophius budegassa* ANK
6. Anglerfish *Lophius piscatorius* MON
7. Blue whiting *Micromesistius poutassou* WHB
8. Grey mullets (*Mugilidae*) Mugilidae MUL
9. Common Pandora *Pagellus erythrinus* PAC
10. Caramote prawn *Penaeus kerathurus* TGS
11. Mackerel *Scomber spp.* MAZ
12. Common sole *Solea solea* (=*Solea vulgaris*) SOL
13. Gilthead seabream *Sparus aurata* SBG
14. Spottail mantis squillids *Squilla mantis* MTS
15. Mediterranean horse mackerel *Trachurus mediterraneus* HMM
16. Horse mackerel *Trachurus trachurus* HOM
17. Tub gurnard *Trigla lucerna* (= *Chelidonichthys lucerna*) GUU

Table 2: Additional species not included in the data collection regulations .

Species common name Species scientific name FAO CODE
1. Sargo breams *Diplodus spp.* SRG
2. Axillary seabream *Pagellus acarne* SBA
3. Blackspot seabream *Pagellus bogaraveo* SBR
4. Greater forkbeard *Phycis blennoides* GFB
5. Poor cod *Trisopterus minutus* POD

2.2. Participants

The full list of participants at SGMED-10-02 is presented in Appendix 2.

3. SGMED 10-02 RESPONSES TO SPECIAL QUESTIONS OF TORS C (STOCK REVIEWS), E (DATA) AND H (SOFTWARE)

3.1. ToR c) Reviews of stocks assessed under other scientific frameworks (anchovy and sardine in GSA 17)

During SGMED-10-02 meeting, SGMED reviewed the stock assessments of anchovy and sardine stocks in GSA 17 (http://151.1.154.86/GfcmWebSite/SAC/SCSA/2009/docs.html) carried out within the framework of FAO-AdriaMed Project and presented at GFCM-SAC-SCSA meeting in 2009 (Malaga, 2009). Results were reviewed and compared with SGMED's previous assessment in 2009 (SGMED-09-02). Significant improvements in the new assessments in relation to previous assessments were noted by SGMED. However, detailed information on input data as number and weight at age by each fleet and country and parameter diagnostics of the assessments are missing in the report. Also, the assessments were conducted using growth parameters (Linf) not in line with previous SGMED recommendations. SGMED noted that both assessments were not based on official DCR data.

SGMED acknowledged that significant improvements were made in the new assessments of both anchovy and sardine (made within the FAO AdriaMed Project framework) in comparison to previous assessments. In previous assessments catch-at-age, weight at age and tuning data were only from the western part of GSA17 (Italian data only), while in the new assessment presented at GFCM-SAC-SCSA meeting in 2009 (Malaga, 2009) the data are from the entire GSA17: (Croatia, Italy and Slovenia). Furthermore, natural mortality vector was calculated in accordance with SGMED-09-01 recommendations using the Gislason's equation and a new tuning series with acoustic biomass estimates covering the entire GSA17 was used.

SGMED conclusions and recommendations:

SGMED acknowledges the efforts made within FAO AdriaMed Project framework and the improvement of the assessment of anchovy and sardine in GSA17 made at GFCM-SAC-SCSA meeting in 2009 (Malaga, 2009). However, SGMED considers that, in absence of detailed information on input data as number and weight at age by each fleet and country, diagnostics of the assessments models and the fact that the use of growth parameters are not in line with previous SGMED recommendations, SGMED is not in the position to endorse the results of these assessments.

SGMED recommends that in future assessments number and weight at age by each fleet and country and diagnostics of the assessments models should be provided in the report. This is crucial to allow for a comprehensive and transparent evaluation of the assessment. Moreover, SGMED reiterates the recommendations that all catch data for sardine in GSA17 including fry fisheries targeting juveniles (data available from EU-SARDONE project) should be included in the assessment. SGMED also recommends the use of Linf in accordance with suggestions made during SGMED-09-01. SGMED suggests that an assessment combining GSA17 and GSA18 should be conducted and that the FLICA assessment model should be tested.

3.2. ToR e) Data policy

Working Group members were reminded that data collected under the DCF call and supplied to SGMED-10-02 for all GSAs could not be used outside the meeting. The data are stored by the EU to enable future assessments under the auspices of SGMED or related groups, to be performed without the need to produce further DCF calls.

3.3. ToR e) Summary of data provided for the Mediterranean through the DCF call 2010

3.3.1. Data call

On the 29th of April 2010 DG MARE launched an official call for data on landings, discards, length and age compositions, fishing effort, scientific trawl and hydro-acoustic surveys in the Mediterranean Sea. Member States were invited to provide, as soon as possible and no later than 22 May 2010, data to the Commission (JRC server for data collection framework DCF) and to the scientists that would attend the forthcoming STECF-SGMED-10-02 meeting in Crete (31 May - 4 June 2010). The meeting was organized in order to assess the status of the Mediterranean stocks and their fisheries in the various GFCM GSAs. Further data on more stocks and on the 2010 surveys are expected to be uploaded before 15 November 2010.

During the SGMED 10-01 working group that took place in Barcelona from 22-26 of March 2010, the definition of a DCF call for biological and economic data to support the work of SGMED in 2010 was included in the discussions. The format of the previous data call was revised to check whether, on the basis of the recommended indicators and methodologies to be applied, changes to the format needed in order to enable data poor assessments. The new data requested include data on two new species (*Spicara smaris* and *Mullus surmuletus),* three more tables (maturity ogive by age, sex ratio at age and age distribution of discards) and for the research surveys at sea (MEDITS), two more table for cross- checking (TD and TT files, Temperature data and codes for the temperature measuring systems and list of hauls per stratum).

3.3.2. Preparatory work

Since the beginning of 2010 and following the requirements of the administrative arrangement with DG MARE, JRC further develop the dedicated DCF website (https://datacollection.jrc.ec.europa.eu/) to make it more user-friendly and accessible for data providers and the appropriate data infrastructures were designed to host the collected data. At the same time, JRC developed quality assurance aspects of the data submitted by Member States by:

a) using **automatic quality checking tool** to check the quality and validate the data provided by Member States,
b) **evaluating the data** provided by Member States and identify missing values,
c) creating **special data structures** (e.g. tables) to allow monitoring of incoming data and its compliance with the requirements of the data call.

More specifically, during the uploading process the following checks were made:

a) **Syntactic** checks: Data type and size (reject any data that does not confirm to the given restrictions, ie. Values > 0, ratios between 0-1, upper and lower bounds of the variables)
b) **Semantic** checks: Constraints on variable values/contents also based on other variables
c) **Completeness** checks (missing values)
d) **Coverage** status of submitted data (years, areas, fleet segments)
e) Data **duplication** checks (double records)

In case of error: an **error message** is produced, with instructions and cell position.

3.3.3. Uploading and data delivery

This was the third year that data were requested by the Member States. During 2008 and 2009, no strict rules concerning the compliance to the upload instructions were applied during the uploading procedure, in order to facilitate the collection of data needed by the relevant SGMED working groups. Some Member States during these two years did not strictly follow the instructions of the data call in the case of the data formats. The lack of compliance resulted in an increased demand for uploading support by the JRC team (frequent application of manual procedures).

In 2010, JRC further developed the dedicated DCF website and applied quality assurance controls on the data submitted by Member States. The data during uploading and before storage in the JRC database were quality checked and wrong codifications; missing or extreme values were identified and the list of errors was reported to the data providers. The files accepted during the uploading process must conform to the templates given as examples on the website. Inconsistencies in the data aggregation and codification were leading to an unsuccessful upload. JRC experts were always monitoring the upload procedure and after consultation with of some of the data providers, necessary modifications to the database were done, in order to facilitate the upload procedure.

The JRC was technically prepared to transmit the data call to the National Correspondents and receive data. Only Cyprus and Slovenia managed to upload through the JRC server most of the data requested by the deadline, on the 22nd of May. France managed to upload most of the biological data on the 26th of May. Spain tried to upload data before the deadline. Following the unsuccessful attempt, the national correspondent submitted the files by email to the JRC email on the 21st of May. Italy also did not manage to upload successfully the requested files and the national correspondent submitted the files by email to the JRC email account on the 27th and 28th of May, the last working days before the SGMED meeting. On the 3rd of June Malta also send data to the Data-collection Team at the JRC through the email account, without trying to use the uploading tool. Greece did not upload any data requested by the 2010 data call.

Despite the shortcomings in the data, JRC experts were able to check the contents and the quality of the data submitted, and prepared the work (abundance and biomass indices, length distribution indices for most species based on the survey data) of the STECF-SGMED meeting. Data provided by email, were made available to the experts attending the SGMED meeting. In certain cases (i.e Malta), the work of the STECF-SGMED working group was impeded due to the lack of official data in order to perform the assessments in specific GSAs, on time.

An overview of the data provided to the SGMED-10-02 meeting by country is presented in Table 3.3.3.1.

3.3.4. Data review and observed deficiencies

Regarding the biological and the survey data, the experts attending the SGMED-10-02 meeting and use the data to produce the assessments were requested to comment in their reports on the quality of the data submitted by the Member States. The comments are included in this report under the relevant stock assessment chapters.

3.3.5. Conclusions and recommendations for future work

In order for JRC to process and prepare the data for the assessment working groups, the datasets need to be available from the EU Member States well in advance (4 weeks) before the beginning of the relevant assessment meetings. No data should be accepted after the deadline for submission. Any progress in data submissions in terms of compliance with uploading procedures and data consistencies will disburden the necessary preparations for the STECF working groups. In addition and in accordance with the provisions of the DCF to allow appropriate data preparation by Member States, SGMED recommends future data calls to be issued at least 2 months in advance of assessment meetings.

Table 3.3.3.1. Overview of DCF data delivery until 31/05/2010 with number of rows and the date of successful upload.

Tablename	CYPRUS	SPAIN	FRANCE	GREECE	ITALY	MALTA	SLOVENIA
0 MED_01_LAN	rows=36 date=2010-05-28		rows=93 date=2010-05-26		rows=8087 date=2010-05-20		rows=1208 date=2010-05-27
1 MED_02_EFF			rows=100 date=2010-05-26		rows=689 date=2010-05-21		rows=172 date=2010-05-21
2 MED_03_LAN_LEN	rows=937 date=2010-05-21		rows=1322 date=2010-05-26				rows=1093 date=2010-05-20
3 MED_04_LAN_AGE	rows=176 date=2010-05-21		rows=82 date=2010-05-26				rows=229 date=2010-05-20
4 MED_05_MAT_LEN	rows=72 date=2010-05-22		rows=247 date=2010-05-26				rows=240 date=2010-05-20
5 MED_06_MAT_AGE	rows=17 date=2010-05-22		rows=6 date=2010-05-26				rows=38 date=2010-05-20
6 MED_07_GRO	rows=2 date=2010-05-22		rows=8 date=2010-05-26				rows=4 date=2010-05-20
7 MED_08_SEX_LEN	rows=124 date=2010-05-25		rows=218 date=2010-05-26				rows=239 date=2010-05-25
8 MED_09_SEX_AGE	rows=18 date=2010-05-25						rows=33 date=2010-05-25
9 MED_10_DIS	rows=2 date=2010-05-25		rows=1 date=2010-05-26				rows=423 date=2010-05-20
10 MED_11_DIS_LEN	rows=31 date=2010-05-25		rows=34 date=2010-05-26				
11 MED_12_DIS_AGE							
12 MED_13_TA	rows=129 date=2010-05-25						rows=28 date=2010-05-20
13 MED_14_TB							rows=819 date=2010-05-27
14 MED_15_TC							
15 MED_16_TD	rows=130 date=2010-05-25						
16 MED_17_TT	rows=129 date=2010-05-25						rows=28 date=2010-05-27
17 MED_18_SP_LEN					rows=352 date=2010-05-21		
18 MED_19_SP_AGE					rows=98 date=2010-05-21		
19 MED_20_SP_MAT							
20 MED_21_CAPACITY			rows=654 date=2010-05-18		rows=374 date=2010-05-20		rows=182 date=2010-05-19
21 MED_22_EMPLOYMENT			rows=62 date=2010-05-18		rows=119 date=2010-05-20		rows=77 date=2010-05-19
22 MED_23_INCOME			rows=105 date=2010-05-18		rows=87 date=2010-05-20		rows=74 date=2010-05-19
23 MED_24_EXPENDITURE			rows=340 date=2010-05-27		rows=317 date=2010-05-20		rows=204 date=2010-05-19
24 MED_25_CAPINVEST			rows=101 date=2010-05-18		rows=138 date=2010-05-20		rows=104 date=2010-05-19
25 MED_26_EFFORT			rows=91 date=2010-05-25		rows=203 date=2010-05-20		rows=76 date=2010-05-19
26 MED_27_LANDINGS			rows=11218 date=2010-05-28		rows=13717 date=2010-05-21		rows=1655 date=2010-05-19

3.4. ToR h) R-scripts and testing

During SGMED 10-01 it was concluded that the R script developed to perform MEDITS survey index standardization was performing correctly the tasks requested such as:

- data exploration
- spatial plotting
- modeling with GLM/GAM
- production of standardized cpue's

The main caveats concerned the errors within the available MEDITS db, the user knowledge of GLM/GAMs and the need to further develop the R script to account for zero inflation.

One recommendation after SGMED 10-01 was to rebuild the MEDITS db according to new specifications. During SGMED 10-02 the new MEDITS db was not available but instead a corrected version of the MEDITS db available during SGMED 10-01 was provided. On this last database attempts to estimate standardized trends in relative abundance ($Kg \cdot Km^{-2}$) were made for the priority species not currently under assessment by SGMED. This exercise aimed at further testing the R script and ideally at deriving reliable trend estimates.

<u>*TOR H.1*</u>

*As a **first priority**, the survey evaluation should allow assessments of trends in stock specific abundance and biomass trends, also age based, not only for the total stock but also separately for the juvenile and adult components.*

In order to assess trends in biomass in those priority species currently not assessed by SGMED (listed in Table 3.4.1), exploratory data analysis was performed using the MEDITS database (SGMED 2009 MEDITS_survey_data_20100601.mdb) available to SGMED.
Trend estimation was performed using the R script developed for SGMED-10-01 (stdindex_MEDITS.r), for script and user manual see SGMED-10-01 web site.

Table 3.4.1 List of priority species for future data calls or assessment.

Species common name	**Species scientific name**	**MEDITS CODE**	**FAO CODE**
1. Bogue	*Boops boops*	BOOP BOO	BOG
2. Common dolphinfish	*Coryphaena hippurus*		DOL
3. Sea bass	*Dicentrarchus labrax*	DICELAB	BSS
4. Grey gurnard	*Eutrigla gurnardus*	EUTRGUR	GUG
5. Black-bellied angler	*Lophius budegassa*	LOPH BUD	ANK
6. Anglerfish	*Lophius piscatorius*	LOPH PIS	MON
7. Blue whiting	*Micromesistius poutassou*	MICM POU	WHB
8. Grey mullets (Mugilidae)	Mugilidae		MUL
9. Common Pandora	*Pagellus erythrinus*	PAGE ERY	PAC
10. Caramote prawn	*Penaeus kerathurus*	PENA KER	TGS
11. Mackerel	*Scomber* spp.		MAZ
12. Common sole	*Solea solea (=Solea vulgaris*)	SOLEVUL	SOL
13. Gilthead seabream	*Sparus aurata*	SPAR AUR	SBG
14. Spottail mantis squillids	*Squilla mantis*	SQUI MAN	MTS
15. Mediterranean horse mackerel	*Trachurus mediterraneus*	TRAC MED	HMM
16. Horse mackerel	*Trachurus trachurus*	TRAC TRA	HOM
17. Tub gurnard	*Trigla lucerna (= Chelidonichthys lucerna)*	TRIG LUC	GUU

The goal was to explore each species in each GSA, to plot the yearly maps with 0 hauls and the cpue, and construct a plot of the observed and predicted mean annual cpue with their confidence intervals derived from fitting a GLM model. The R script queries the MEDITS database for one species and one GSA at a time. The data by weight was extracted from the MEDITS database via a query using RODBC. The data from file TA and TB are merged and further data manipulations are made in order to run the models (See User Manual). If data from 2 different GSAs are returned, this error can generate bias in the estimates of the trends (see example in GSA 06). The queries used data only stored in files TA and TB of the MEDITS database but not TC.

At this stage it was decided to adopt the same standardization GLM model for all species and GSA. The model estimates the cpue based on the effects of Year, Month, Depth and the interaction of Longitude and Latitude, and, relies on a Quasi-Poisson family distribution and a log link function. The Quasi-Poisson family was used as it can deal with a moderate number of zeroes and over-dispersion in the data. Cpue is defined as $Kg \cdot Km^{-2}$ and the model in R code is the following:

```
mod <- glm(CPUE~factor(YEAR)+factor(MONTH)+Latitude*Longitude+DEPTH, family=quasipoisson, data=TB)
```

A full model selection and model diagnostic was not performed and zero inflation was not accounted explicitly. As a consequence, in many cases the model and the family distribution used are not appropriate and thus model prediction can return incorrect values. Proper model fitting and selection steps need to be carried out to have reliable model fits, predictions, standardization and trends for each combination of species and GSAs. As serious problems with the MEDITS data were identified (i.e., described in the next section), it was not considered worthwhile spending time on model fitting and model selection as results in many cases would have not been reliable. However, model fitting remains an important task to perform for a full standardization of the survey data.

Among the priority species several are never or very rarely caught by the MEDITS survey and are therefore difficult to use for assessment purposes.

GSA 06

The query to GSA 06 returns cpue (Kg·Km^{-2}) values for all the species queried except *Sparus aurata*. There are problems with year 1994 as only two hauls seem to have been performed (Figure 3.4.1) and for years 2007, 2008, 2009 when data from GSA 05 are erroneously included in the plots and thus also in the models. Therefore the trends of all the species (Figure 3.4.2) are biased as the initial part of the series refers only to data from GSA 06 while after 2007it also includes GSA 05.

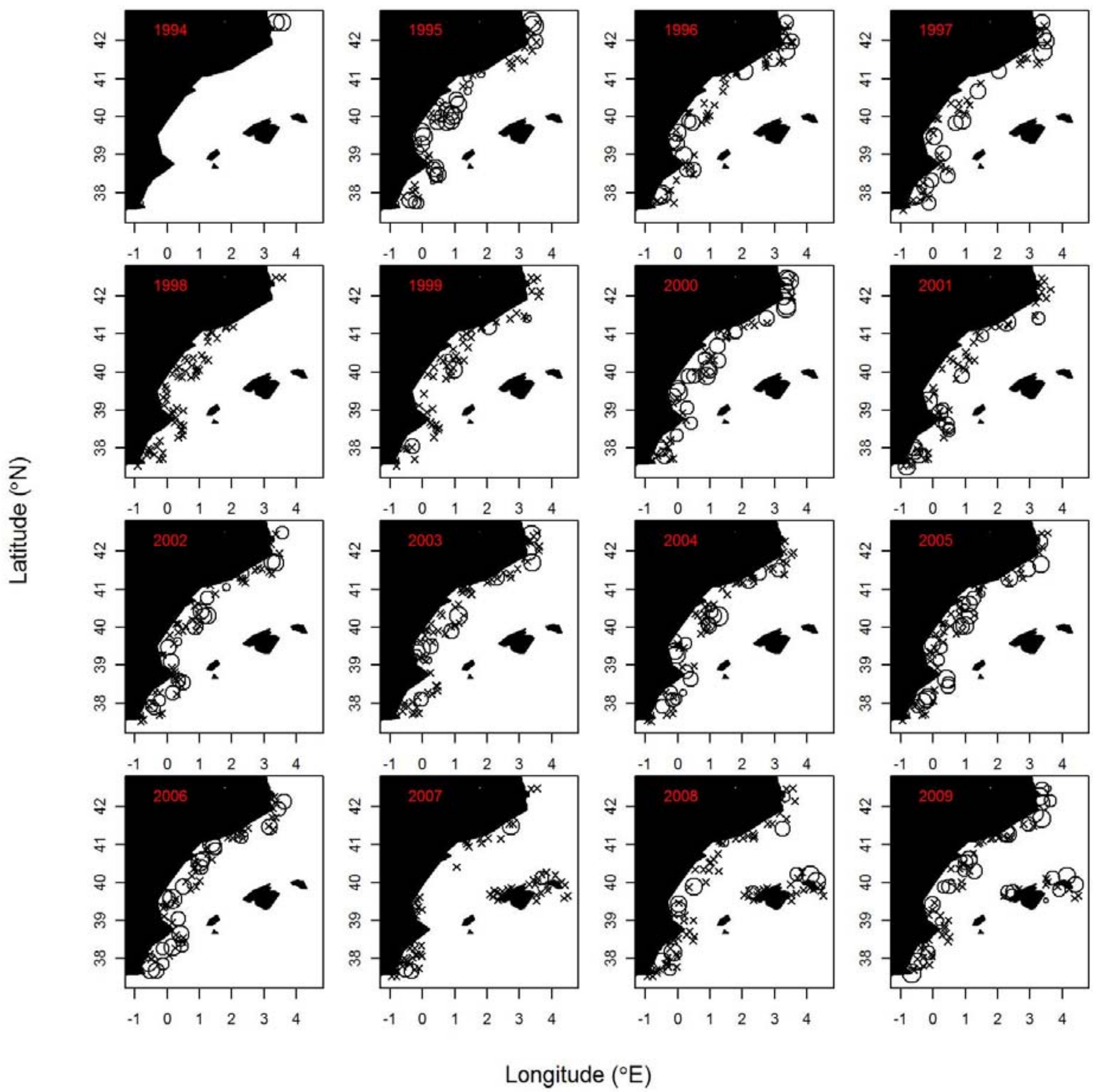


Fig. 3.4.1 Zero hauls and cpue (Kg·Km^{-2}) for *Lophius budegassa* in GSA 06 from MEDITS. Missing information in 1994 and from 2007 to 2009 data belonging to GSA 05 is erroneously included.

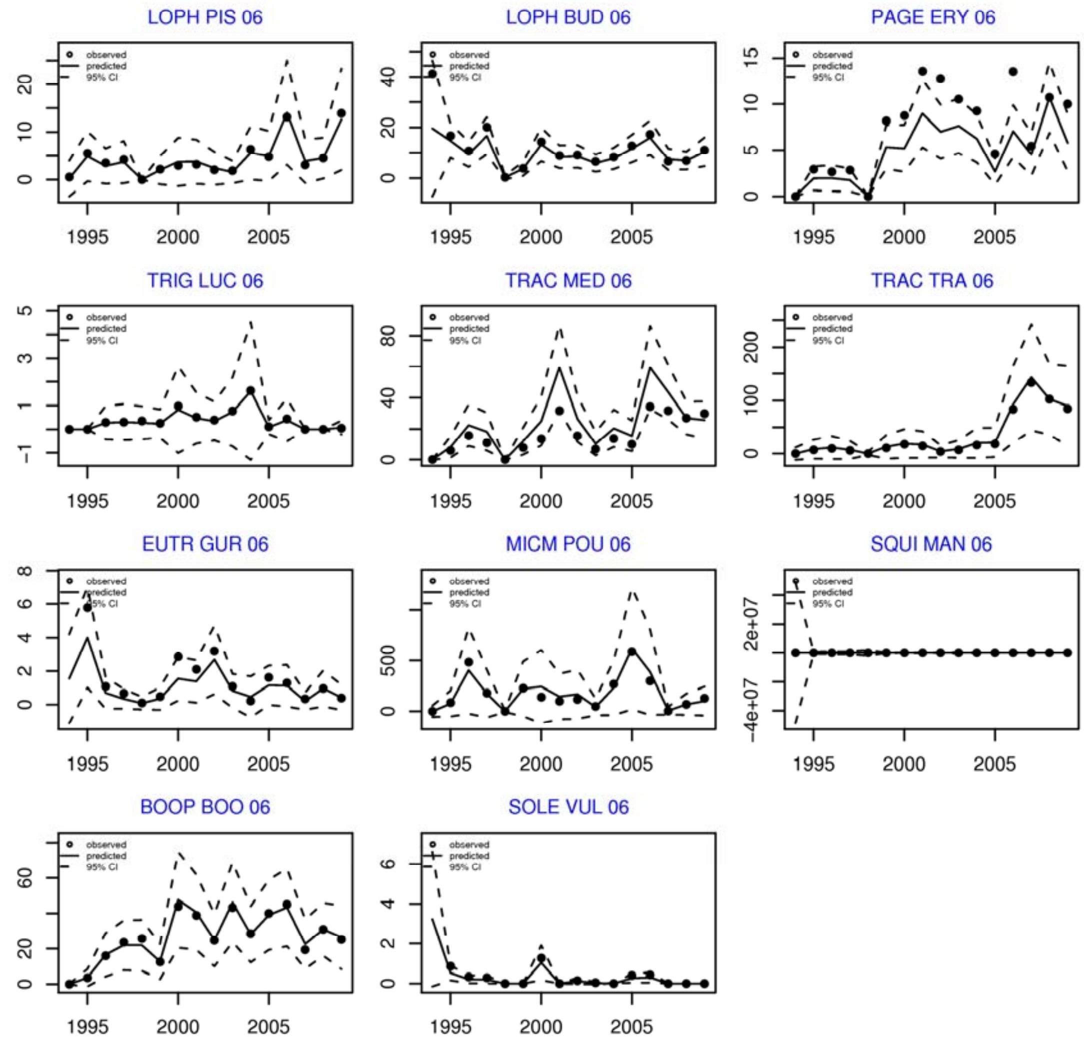


Fig. 3.4.2 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 06 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trigla lucerna* (TRIG LUC), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Squilla mantis* (SQUI MAN), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL).

GSA 07

The MEDITS database seems accurate and the main problem is the lack of parameters that would allow the swept area estimation in 2004 (Figure 3.4.3). No *Sparus aurata* data was returned from the query.

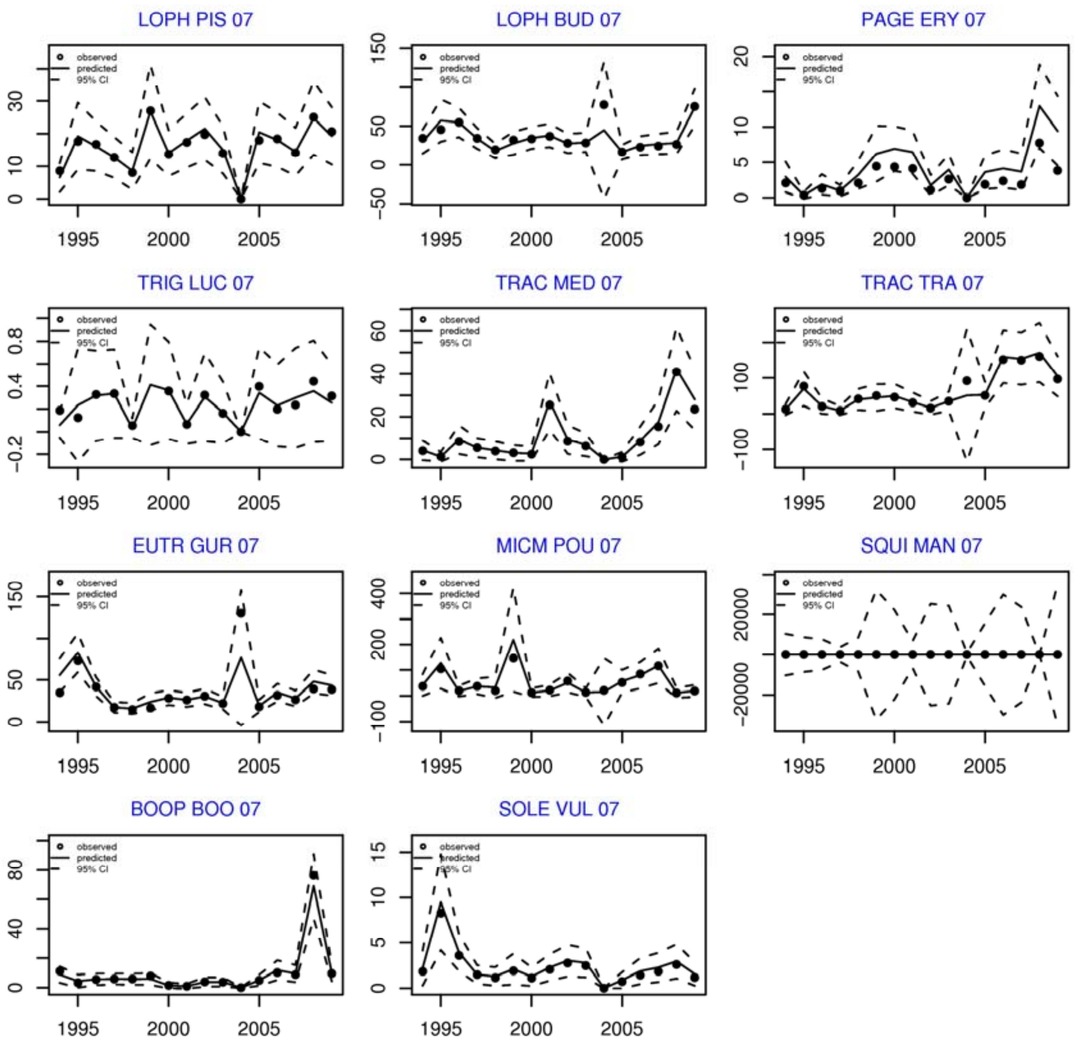


Fig. 3.4.3 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 07 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trigla lucerna* (TRIG LUC), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Squilla mantis* (SQUI MAN), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL).

GSA 08

The MEDITS database returns the same errors with swept area parameter as in GSA 07 and for some reason the CI in 1995 is extremely large and this should need further investigation (Figure 3.4.4). No *Sparus aurata, Squila mantis* and *Trigla lucerna* data were returned from the query.

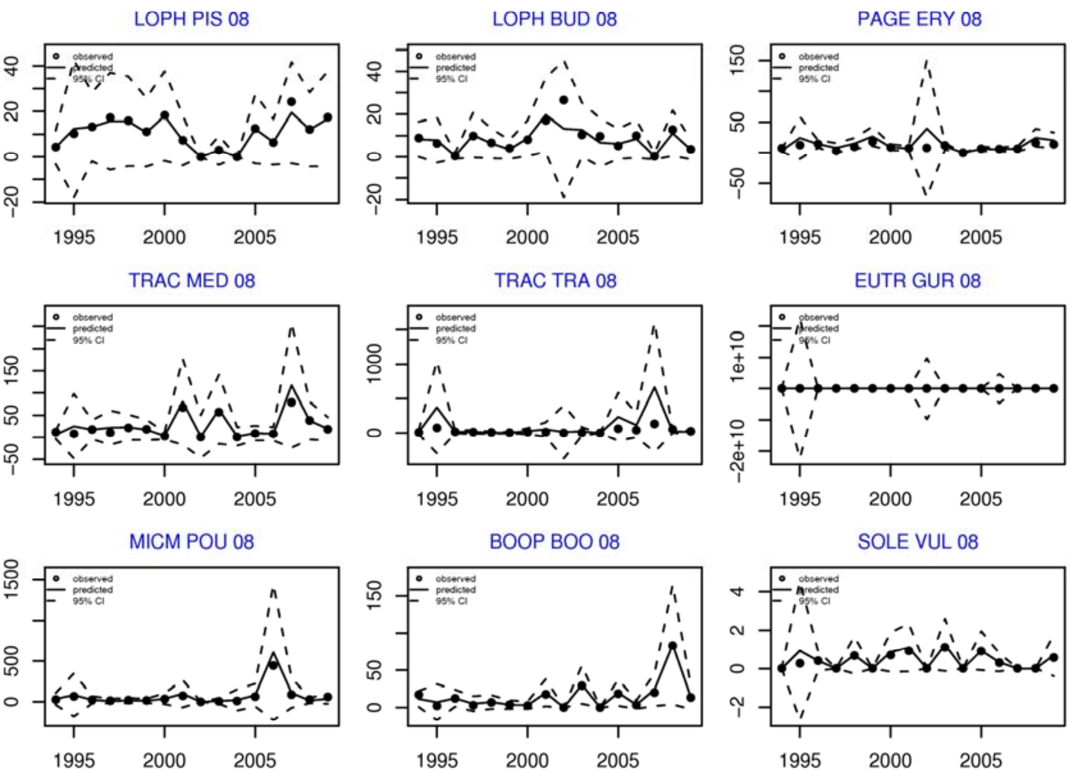


Fig. 3.4.4 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 08 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL).

GSA 09

The data from this GSA from the MEDITS database seems mostly correct although the dates of some hauls are in September and October while the MEDITS survey is performed in May, June and July. All species queried are returned and the trends displayed in the cases of LOPH PIS, PAGE ERY, TRIG LUC, EUTR GUR and SPAR AUR appear flat because of a scaling problem with the CI. There are inconsistencies with 2007 data as the CI's for all species selected are either very large or absent (Figure 3.4.5).

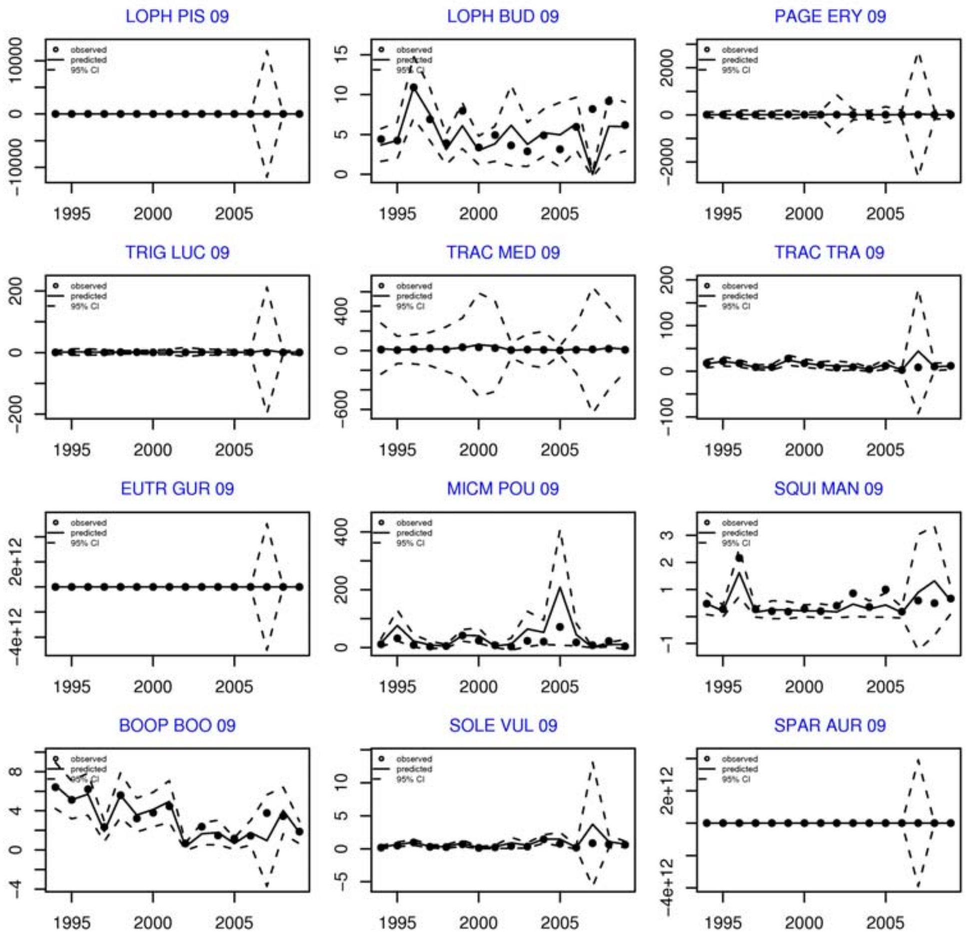


Fig. 3.4.5 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 09 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trigla lucerna* (TRIG LUC), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Squilla mantis* (SQUI MAN), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL), *Sparus aurata* (SPAR AUR).

GSA 10

The main inconsistency found in the JRC MEDITS dataset of the GSA 10 is the inclusion of hauls belonging to GSA 09, as reported in the SG-MED 10-01 report. Other noticeable inconsistencies were not found. After having redefined the query of the SGMED 2009 MEDITS_survey_data_20100601.mdb, using Medits GSA 10 geographical definition, all species queried are returned and the trends displayed. These appear flat in the cases of SOLE VUL and SPAR AUR because of a scaling problem with the CI. These species were rather rare in the GSA Medits surveys, while the species EUTR GUR was never caught (Figure 3.4.6). Working on model selection and factors will improve the model fitting, as the choice of using the same model for all species and GSAs seems not appropriate.

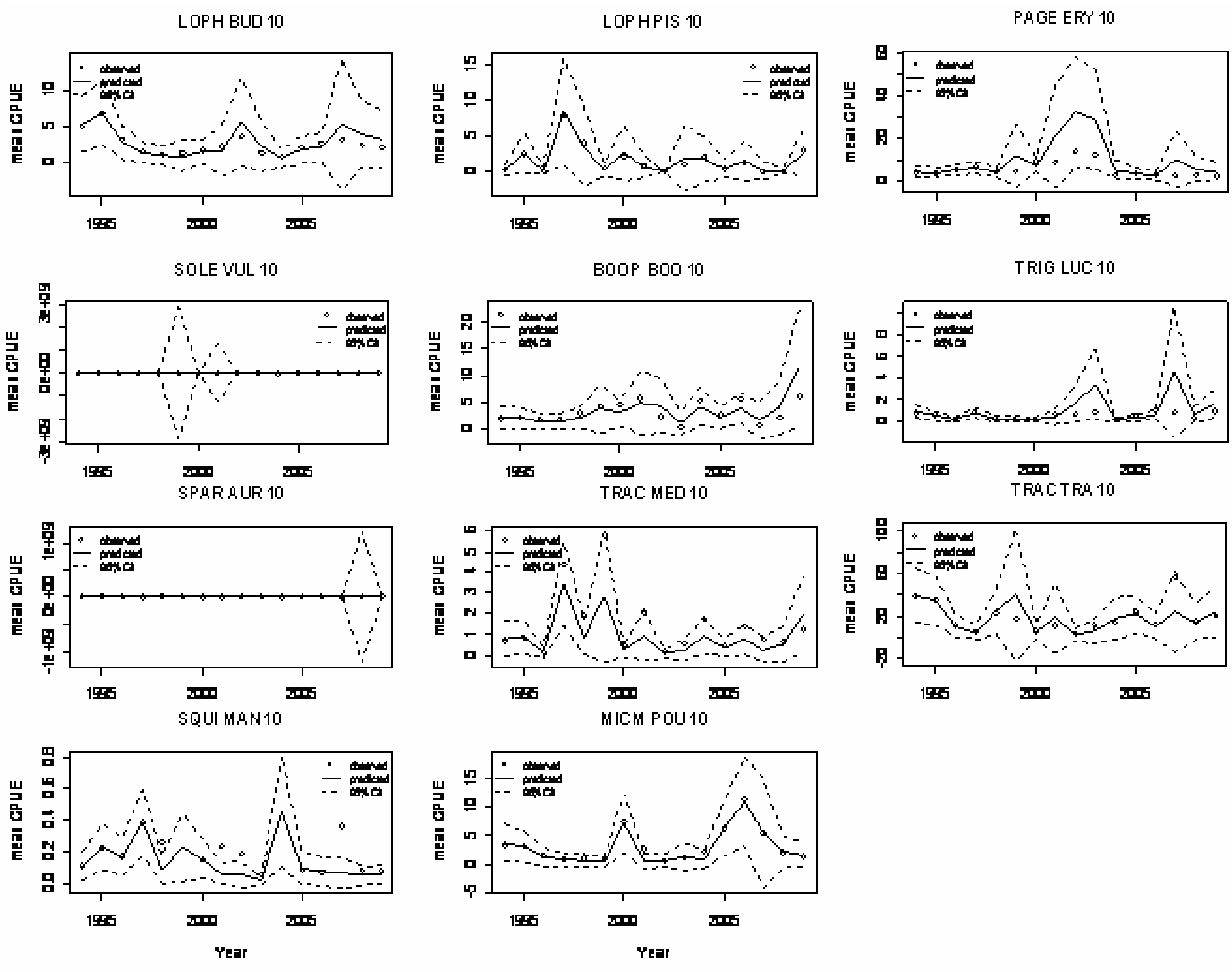


Fig. 3.4.6 Mean observed and predicted (+/- 95% CI) cpue ($Kg \cdot Km^{-2}$) trends over time in GSA 10 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY),), *Solea vulgaris* (SOLE VUL), *Boops boops* (BOOP BOO), *Trigla lucerna* (TRIG LUC), *Sparus aurata* (SPAR AUR), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Squilla mantis* (SQUI MAN), *Micromesistius poutassou* (MICM POU).

GSA 11

In this GSA there are inconsistencies within the MEDITS database as LOPH PIS, PAGE ERY, TRIG LUC, TRAC TRA and BOOP BOO are not returned from the query but are present in the MEDITS database. Some NA's are present in the SEX column of TC file and make the R script crash when data are processed. The trends of the remaining species, plotted in Figure 3.4.7, seem informative although there are large CIs for all species in 2006 that requires further investigation.

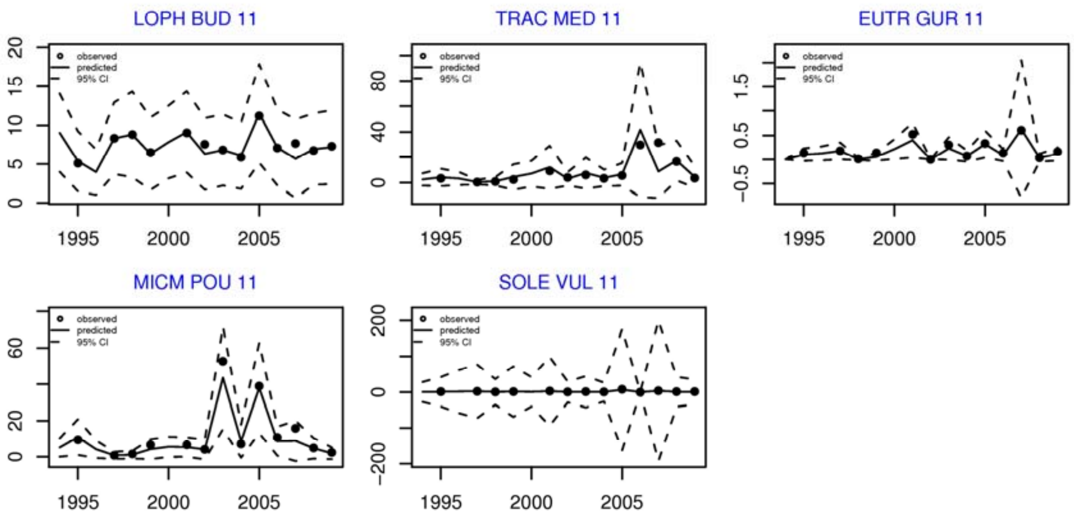


Figure 3.4.7 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 11 for *Lophius budegassa* (LOPH BUD), *Trachurus mediterraneus* (TRAC MED), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Solea vulgaris* (SOLE VUL).

GSA 16

The MEDITS database contains information for all species except *Squilla mantis* and *Sparus aurata* which are present in the MEDITS database but are likely to contain errors that prevent the run of the R script. Additional errors are Lat and Long with wrong decimals for 2006 and the inclusion of hauls performed by Malta in GSA 16. In the case of *Lophius piscatorius* and *Pagellus erythrinus* the data are zero inflated and the model is not performing well and different models should be used for those species (Figure 3.4.8).

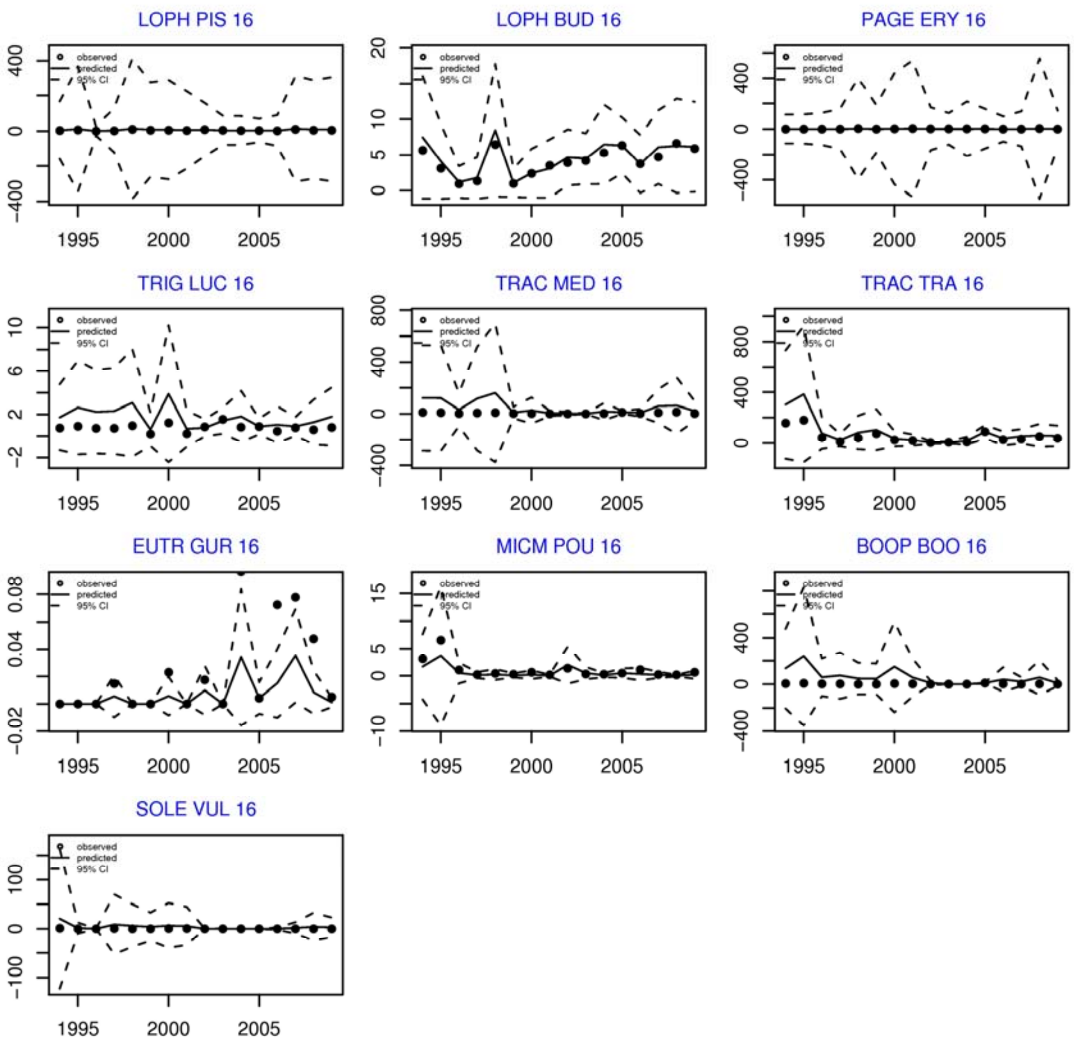


Fig. 3.4.8 Mean observed and predicted (+/- 95% CI) cpue ($Kg{\cdot}Km^{-2}$) trends over time in GSA 16 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trigla lucerna* (TRIG LUC), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL).

GSA 17

There are major problems with the availability of MEDITS data for GSA 17. Years 1994, 1995, 1996, 1997, 1998, 1999, 2000 and 2001 are completely missing for target and non target species as the data has never been made available for stock assessments to SGMED. Additionally in year 2002 and 2003 survey data is available for Italy, Slovenia and Croatia while in the remaining years data are available only for Italy (Figure 3.4.9 and 3.4.10). The temporally truncated series, lacking 8 years of data, and the spatial unbalance (i.e. missing hauls from the eastern part of the GSA 17) seriously halts any attempt of assessing the status of the demersal resources in this GSA using trawl survey data. Thus, the trends displayed in Figure 3.4.10 are biased because of the spatial unbalance in the data between East and West side of the Adriatic and the lack of information before 2002. GSA 17 is an important fishing area in the Mediterranean Sea and the impossibility of performing stock assessment because of lack of data is a matter of concern.

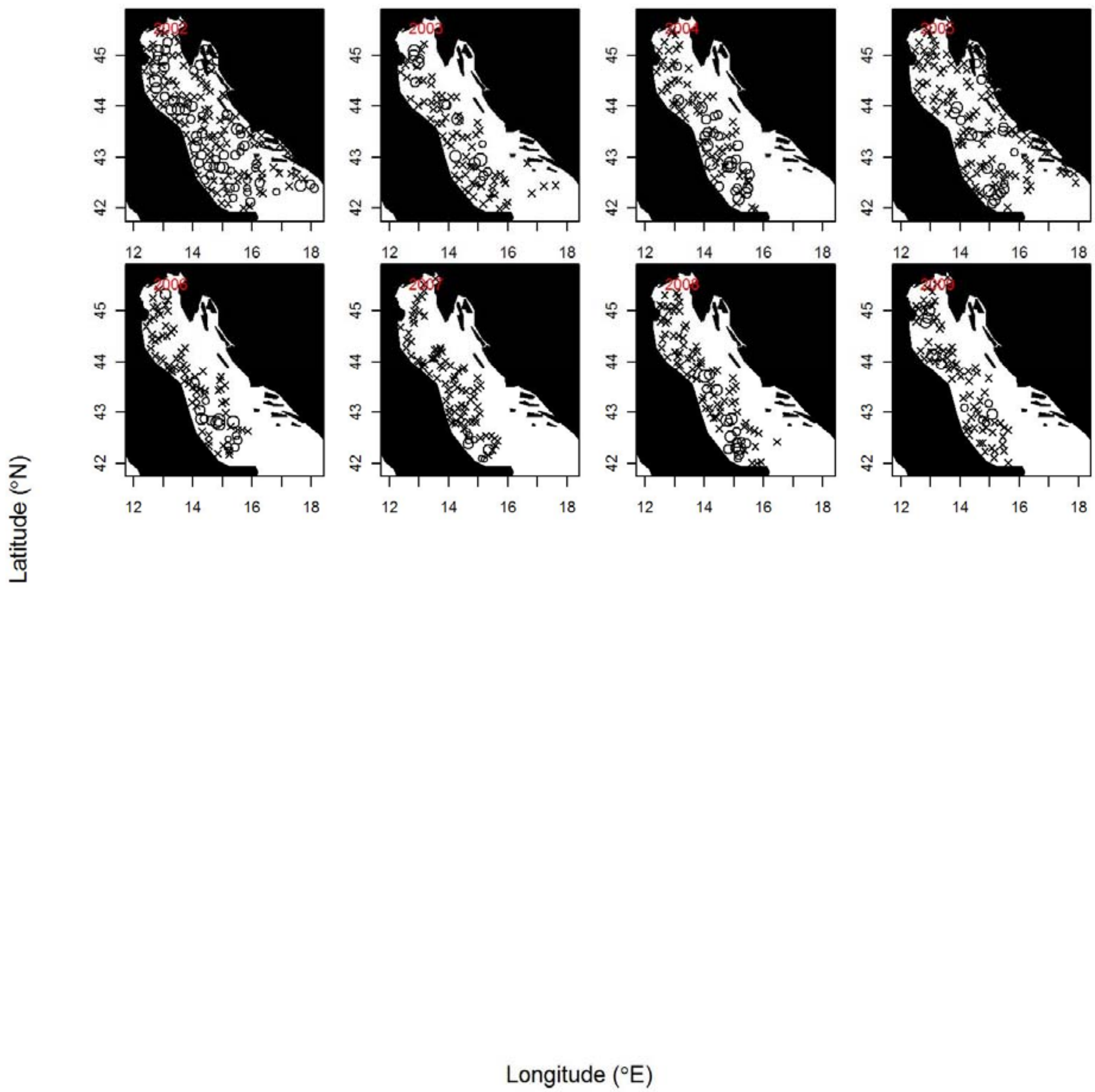


Fig. 3.4.9 Example map of 0 hauls and cpue (Kg·Km^{-2}) for *Nephrops norvegicus* in GSA 17 from MEDITS. All data are missing from 1994 to 2001 and there is spatial unbalance in data availability between the East and West side of the basin.

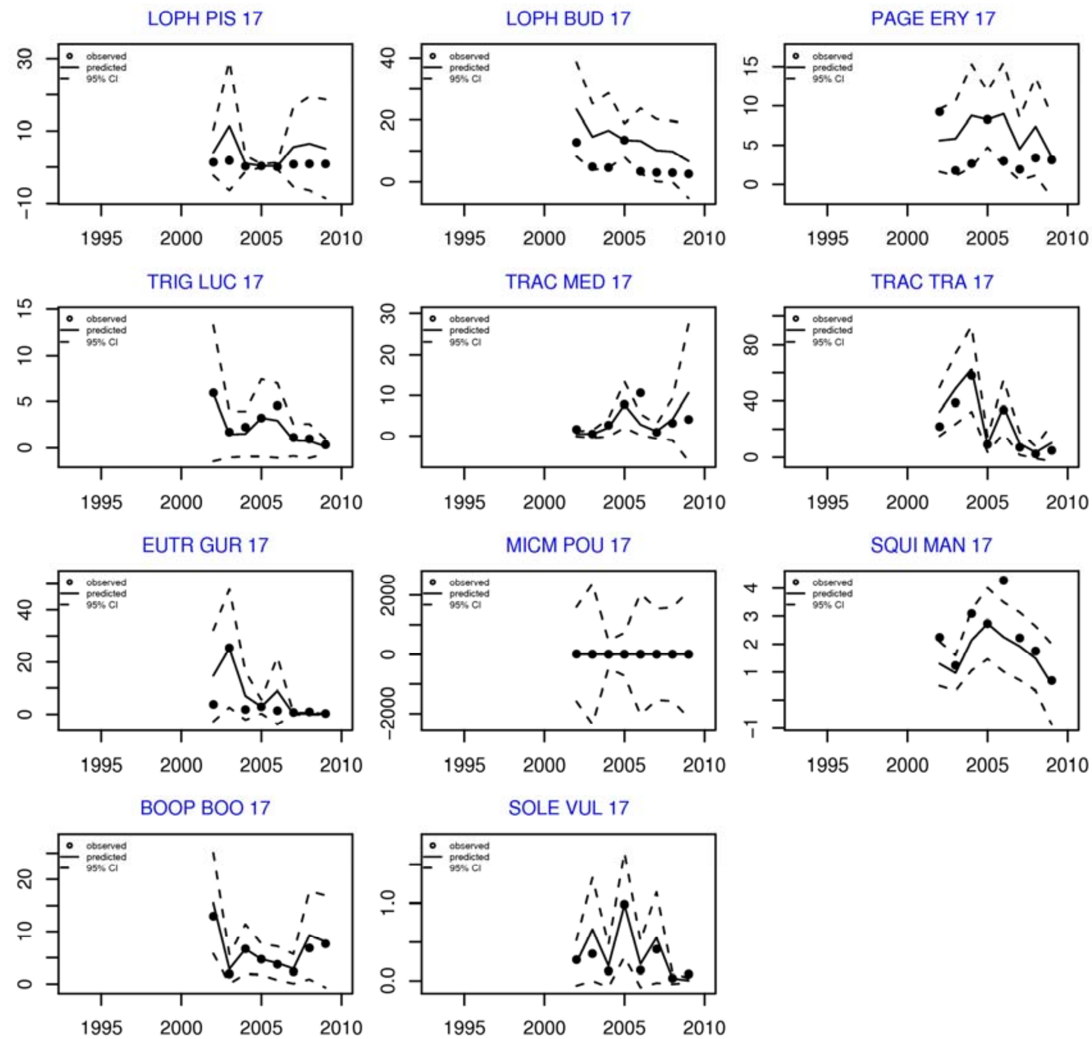


Fig. 3.4.10 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 17 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trigla lucerna* (TRIG LUC), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Squilla mantis* (SQUI MAN), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL). All species data from year 1994 to 2001 is missing and the observed and predicted means are biased because of the spatial unbalance in the data.

GSA 18

Medits data from GSA 18 is available for the entire survey period with the exception of 1994. For all available years data from GSA 18 comes from Italy, but in 2002-2004 are included 32 hauls from Albania and in 2002 one haul from Croatia. The fitted model captures well the temporal trend with the exceptions of *Pagellus erythrinus, Trigla lucerna* and *Solea vulgaris* which are likely zero inflated and need different models (Fig. 3.4.11).

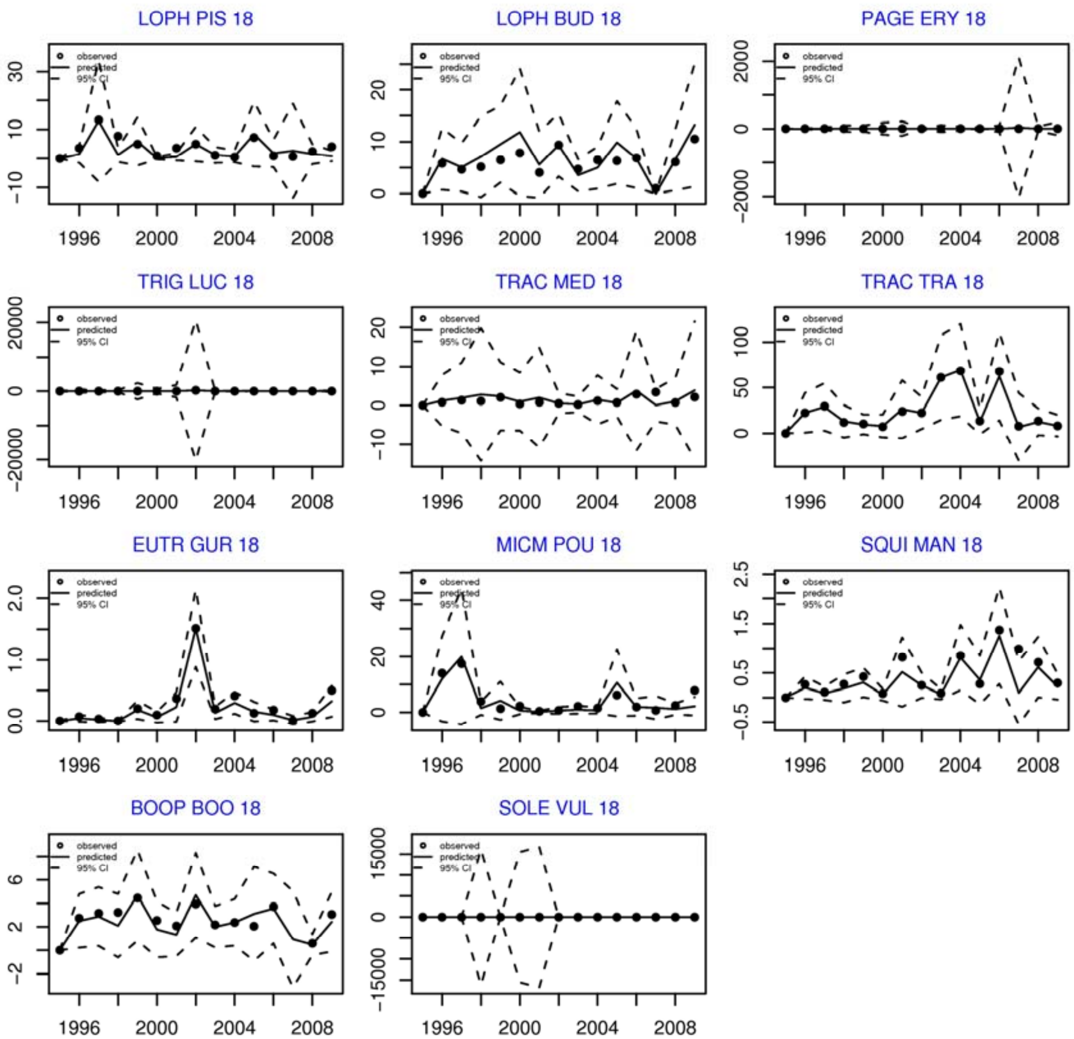


Fig. 3.4.11 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 18 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trigla lucerna* (TRIG LUC), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Squilla mantis* (SQUI MAN), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL).

GSA 20

Medits data from GSA 20 is available all years with the exceptions of 2002, 2007 and 2009. The number of hauls has doubled over time going from 12 in 1994 to approximately 30 after 1998. The trends estimated by the GLM seem realistic for all species with the exceptions of *Lophius piscatorius* and *Micromesistius poutassou* that are likely zero inflated and will need further modeling attempts.

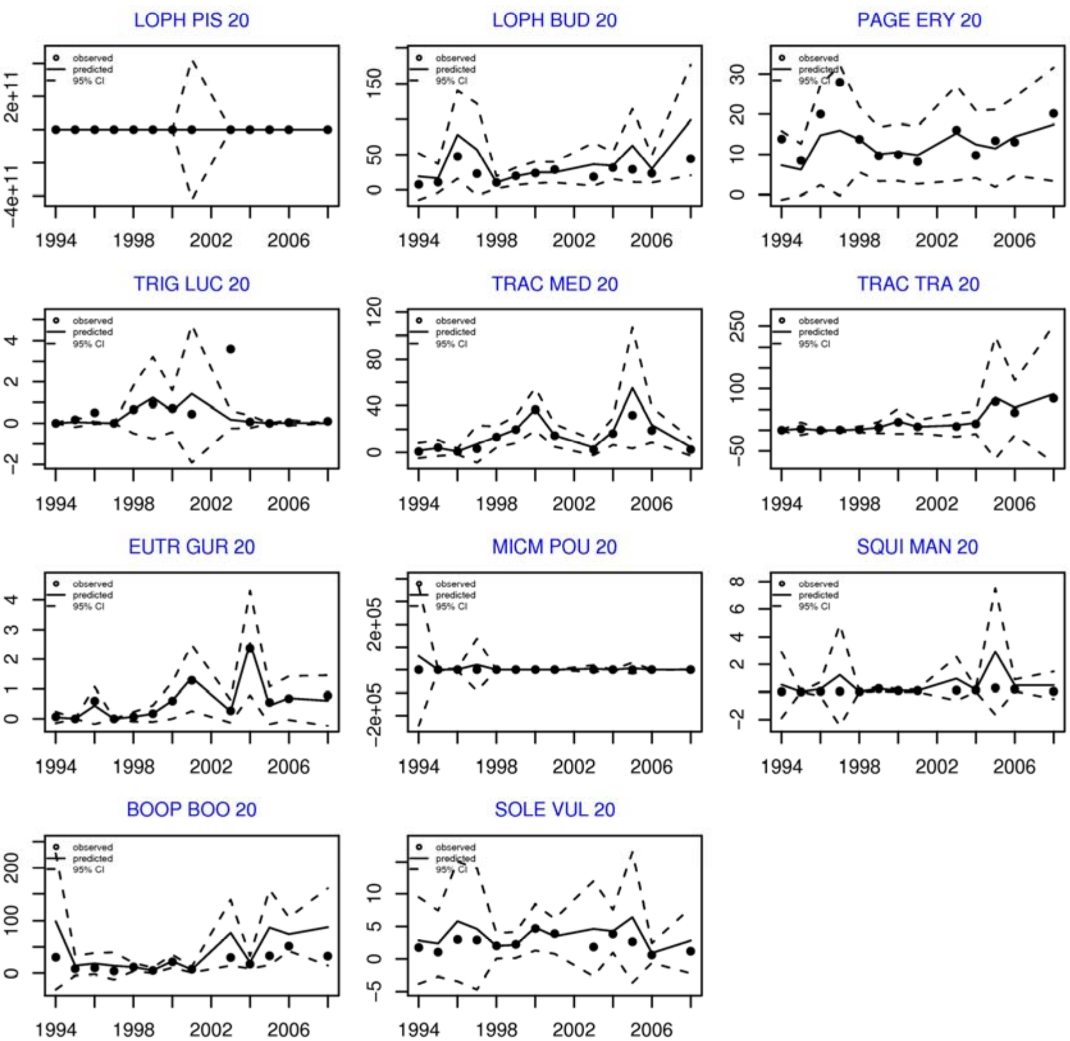


Fig. 3.4.12 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 20 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trigla lucerna* (TRIG LUC), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Squilla mantis* (SQUI MAN), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL).

GSA 22+23

Data from year 2002, 2007 and 2009 is missing and over time there has been an increase in the number of hauls performed in these joint GSA's. In 1994-95 around 100 hauls were performed by one boat (IRO) while in the following years the hauls increased to approximately 150 with multiple boats (DEM, EVA,NAU and PAR) participating to MEDITS during the same years. In the current models a boat factor is not included. For all species of interest the models return realistic trends with the exception of *Sparus aurata* which is absent from the database (Fig. 3.4.12).

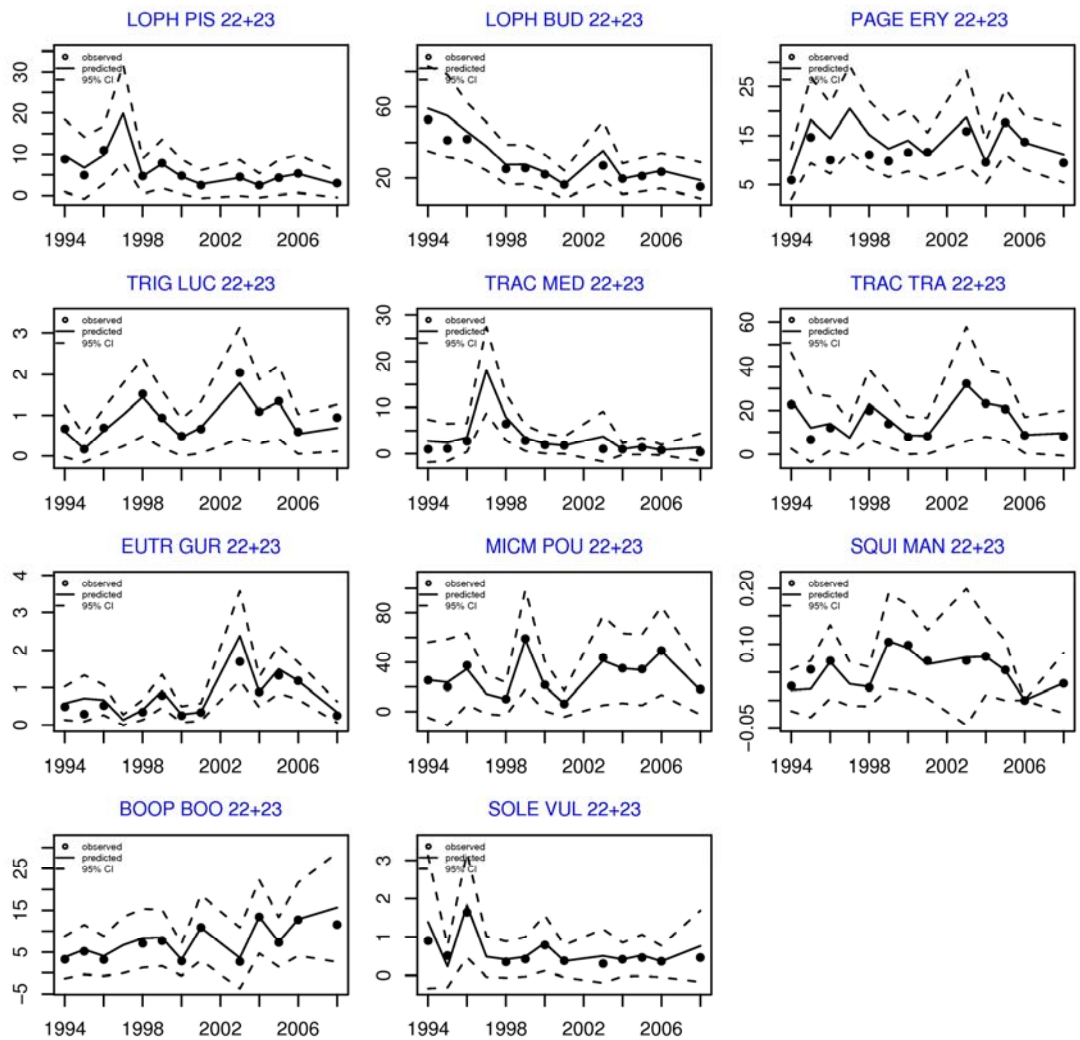


Fig. 3.4.12 Mean observed and predicted (+/- 95% CI) cpue (Kg·Km^{-2}) trends over time in GSA 22+23 for *Lophius budegassa* (LOPH BUD), *Lophius piscatorius* (LOPH PIS), *Pagellus erythrinus* (PAGE ERY), *Trigla lucerna* (TRIG LUC), *Trachurus mediterraneus* (TRAC MED), *Trachurus trachurus* (TRAC TRA), *Eutrigla gurnardus* (EUTR GUR), *Micromesistius poutassou* (MICM POU), *Squilla mantis* (SQUI MAN), *Boops boops* (BOOP BOO), *Solea vulgaris* (SOLE VUL).

Conclusions

Based on the trends in biomass, the priority species for which the MEDITS database seems to be informative to identify trends are listed in Table 3.4.2 below. Several species are either zero inflated or present database problems. Overall it is difficult to assess whether the standardized cpues are reliable or not given the errors detected. For some GSAs like 06 the trends are certainly biased in the more recent year, while in other GSAs there are scattered yearly errors.

Table 3.4.2 List of priority species by Medits code and GSA. Enough data is available for trend estimation (YES), not enough data for trend estimation (NO), status of the data unclear due to errors in database (na, ?) or occasional occurrence of the species in the surveys.

GSA	LOPH PIS	LOPH BUD	PAGE ERY	TRIG LUC	TRAC MED	TRAC TRA	EUTR GUR	MICM POU	SQUI MAN	BOOP BOO	SOLE VUL	SPAR AUR
6	YES	YES	YES	?	YES	YES	YES	YES	NO	YES	?	na
7	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	na
8	YES	YES	YES	na	YES	YES	no	YES	na	YES	?	na
9	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	no
10	YES	YES	YES	YES	YES	YES	NO*	YES	YES	YES	NO*	NO*
11	na	YES	na	na	YES	na	YES	YES	na	na	?	na
16	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	?	NO
17	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	?	NO
18	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	?	NO
20	?	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
22+23	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	
0 Infl.				yes							YES	

*rare presence or absence of the species during the surveys

As anticipated, the errors in the current Medits db although improved from the version available for SGMED 10-01, can either make the R script crash or can return misleading trends. The R script for cpue standardization performs well, unless there are errors that should not be in the database. The user can detect and correct the errors in order to run the script, however correcting errors in a db is arbitrary, time consuming, difficult to track and the results might be unreliable.

It is clear that applying the same model to different species and GSAs is not the best approach. For each species and GSA there should be an in depth model exploration and stepwise model selection. This would require with the current species/GSAs combinations doing a model selection for 132 different cases, which is an extremely large task for a working meeting. In addition good skills with R and statistical knowledge of GLM/GAMs are necessary from the user.

During MEDITS there has been changing number of hauls within the same areas as in GSA 16, 20 and others. This can have a significant impact on the calculation of the cpue using the standard method of stratified means. In these cases it is particularly important to perform cpue standardization with GLM/GAMs in order to account for sampling unbalance over time and the effect of adding/removing certain hauls.

Recommendations

1. If fast and routine use of MEDITS data stored in the SGMED database is a foreseeable goal, a reliable and error free database should be made available for stock assessment.
2. It is advisable to assess the cost benefit of performing and using standardized versus un-standardized cpues for stock assessment within SGMED. As MEDITS index often drives the tuning of XSA assessment this matter is important.
3. A dedicated working group should perform an in depth effort to standardize MEDITS cpues for main target and priority species using the R script. Such work will determine which models work best for certain species and areas. Once this has been done the first time, updating the models the following years will be a routine exercise that requires only re-running the same models.

4. The same working group should retain the most common models used to fit MEDITS cpue data and incorporate them in the R script developed so far (and manual) so that the end user has multiple predefined sets of models. These models should be scripted with their corresponding model predictions as this part can be difficult to modify by a non expert user. It is advisable that the R script will be able of fitting Zero inflated models and dealing with heterogeneity (spread of the residuals along an explanatory variable) as both cases are very common with fisheries survey data.

R code testing- Length slicing

The code for the length slicing routine in R that was developed during SGMED 10-01 was updated to improve the interface with the database access script. It was also modified to make the code more robust to user and data errors. The slicing methodology remained the same as before and is based on calculating the proportion of the length groups that falls within each age group, given the von Bertalanffy growth parameters L_{inf}, K and t_0.

During SGMED 10-01 the results from the original length slicing code was shown to be consistent with the results from FLDA. The updated code was also found to be consistent with these results (Fig. 3.4.13).

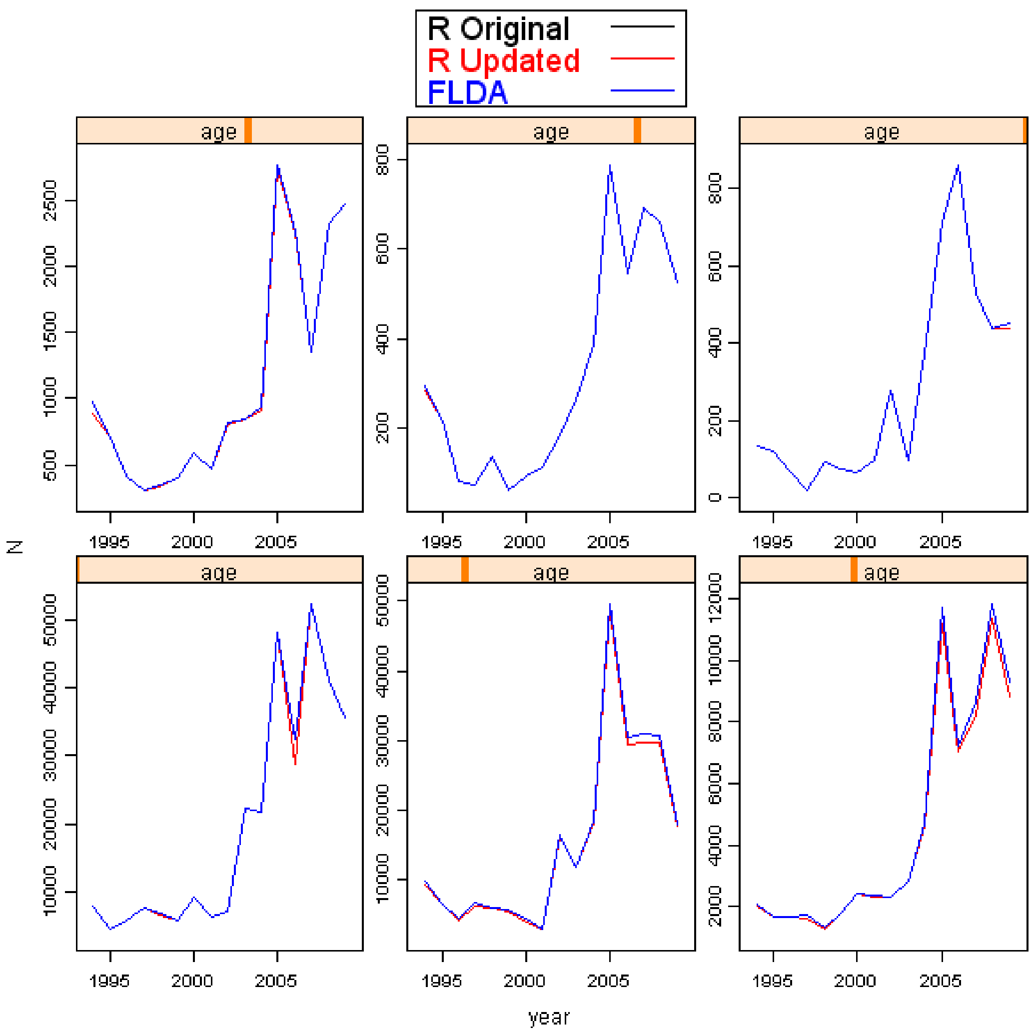


Fig. 3.4.13 Checking the consistency of the updated length slicing routine in R. Species shown is hake in GSA 16. The results from the updated script are identical to the original R script developed in March and also consistent with the results from FLDA.

Repeating this consistency test using the current version of the MEDITS database showed that some of the results were different to the results from database used SGMED 10-01 (Fig. 3.4.14). This again highlights problems with the current version of the MEDITS database.

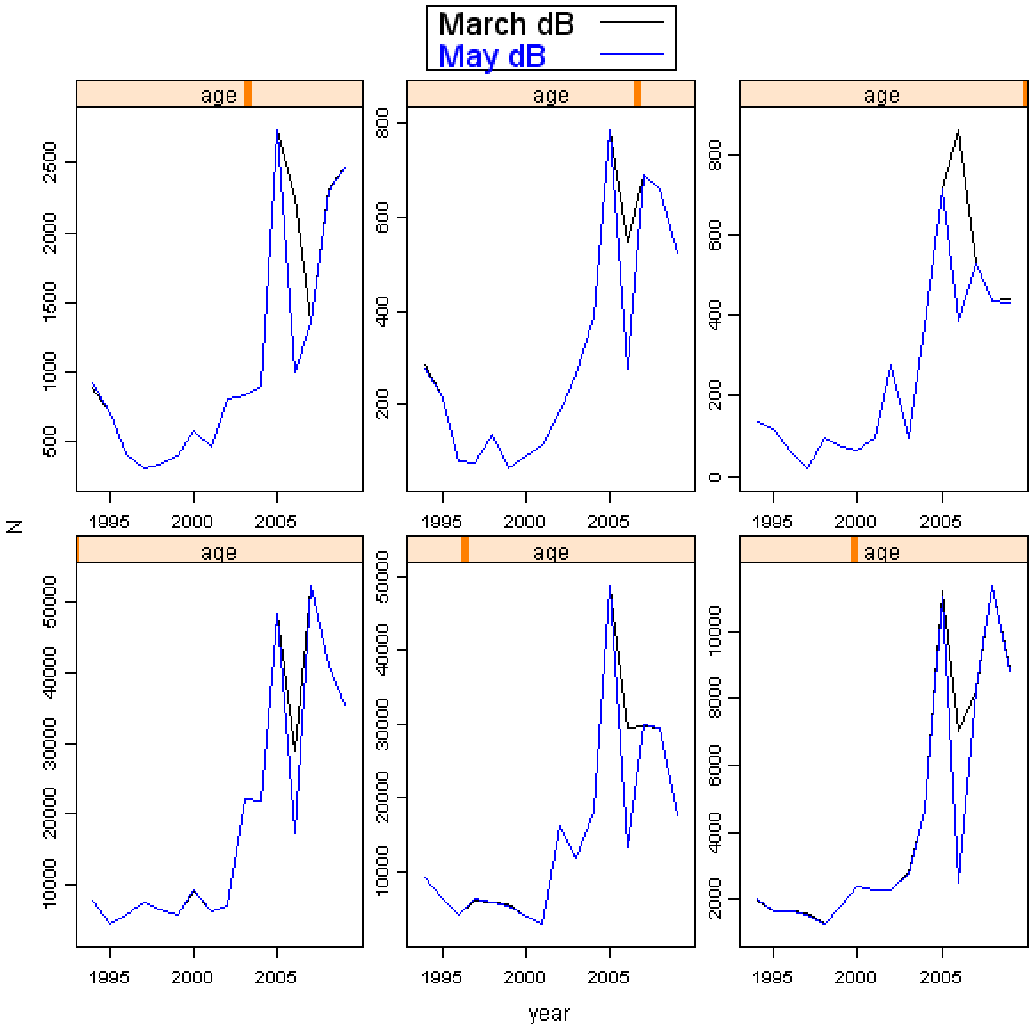


Fig. 3.4.14 An example of the difference between the MEDITS database used in SGMED 10-01 and that available at SGMED 10-02. The stock shown is hake in GSA 16.

Conclusions and recommendations

The age slicing function developed within the R script performs well and can be used for routine slicing, although more testing would be advisable with different species like shrimps.

Given the time constraints, no time was spent in the standardization of the CPUE of the Age classes. This task remains very important and should be further tested.

It was also not possible to perform comparative SURBA assessments with numbers at age standardized using appropriate models and empirically rised to the surface or time units. This remains an important aspect that needs to be investigated in order to assess the benefits and cost of doing the time consuming step of index standardization.

4. Stock summary sheets

SGMED 10-02 provides 38 stock summary sheets (short versions of the important information from the assessment sections of this report, section 5) only in cases where exploitation rates are estimated analytically. Fisheries management advice is provided in cases that limit management reference points of exploitation consistent with high long term yields could be quantified.

The summary sheets provided in this report of SGMED-10-02 deal with assessment of historic and recent trends in stock parameters (stock size, recruitment and exploitation) and relevant scientific advice only. Deterministic short and medium term predictions of such parameters including landings and stock size under various management options as well as relevant scientific advice will be delivered through the forthcoming SGMED-10-03 meeting (13-17 December 2010). However, long term forecasts are provided in order to allow stock status reviews with regard to the estimated limit management reference points $F_{0.1}$ and F_{MSY}.

4.1. Hake in GSA 05

Species common name:	Hake
Species scientific name:	*Merluccius merluccius*
Geographical Sub-area(s) GSA(s):	GSA 05

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the SSB. SSB showed important oscillations during the data series, with maximum values in the middle of the series (1990s) and with a slight decreasing trend during the last years.

- State of the juvenile (recruits):

Although recruitment also showed important oscillations, high values (around 8.5 millions) found in the 1980s and 1990s were not been repeated since then. In the most recent period, there is a maximum (around 6 millions) in 2005, but with an increasing trend since then. Recruitment in 2009 is estimated to be the lowest since 1980.

- State of exploitation:

SGMED-10-02 proposes $F_{0.1}$=0.22 as limit management reference point consistent with high long term yields. Mean fishing mortality over ages 0 to 4 years showed oscillations during the entire data series, although it has been quite stable during the last 5 years. The vector of fishing mortality over age displays a typical selection curve and shows that the highest fishing exploitation is estimated for 1 and 2-year-old individuals and also that the exploitation of the recruits (age 0) is very low. The current F_{ref} (0.84) is above the Y/R $F_{0.1}$ reference point (0.22), which indicates that hake in GSA 05 is overexploited.

- Source of data and methods:

Landings time series from 1980 to 2009 from the bottom trawl fleet of Mallorca. Length frequency distributions from monthly on board or on port samplings developed between 1980 and 2009. The biological parameters used for the assessment, obtained in the framework of the Spanish Data Collection Program, were used. Natural mortality at age was calculated using the PROBIOM spreadsheet. Stock parameters were estimated by means of XSA. YpR analysis was applied to estimate management reference points.

Outlook and management advice

The stock status indicators showed that the resource is overexploited (F_{ref}>$F_{0.1}$). SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated. A part of the catches is under the minimum landing size. In this sense, the improvement of the trawl exploitation patterns imply further increases in potential landings.

Short, medium and long term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

In the Balearic Islands (GSA 5), commercial trawlers employ up to four different fishing tactics (Palmer et al. 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Guijarro & Massutí 2006; Ordines et al. 2006). Vessels mainly target striped red mullet (*Mullus sumuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The

Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered monospecific. Recent annual landings of hake are in the order of 70 t.

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{lim} (age range)=	
$F_{0.1}$ (0-5)=	≤0.22
F_{max} (0-5)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

E_{lim} (age range)=	
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 05 can be found in section 5.3 of this report.

4.2. Hake in GSA 06

Species common name:	European hake
Species scientific name:	*Merluccius merluccius*
Geographical Sub-area(s) GSA(s):	GSA 06

Most recent state of the stock

- State of the adult abundance and biomass (2002-2009):

During 2002-2004 SSB oscillated between 600 and 750 t. SSB peaked in 2007 (1,670 t) and at present (2009), SSB is estimated to be around 1,300 t. This value of SSB is significantly below the proposed B_{lim}=2,200 t and B_{pa}=4,000 t (SGMED-09-02 report).

- State of the juvenile (recruits):

Recruitment has been low in recent years and has decreased to the lowest level observed in 2009.

- State of exploitation:

SGMED 10-02 recommends F≤0.2 as limit management reference point (basis $F_{0.1}$). Comparing this reference with $Fbar_{02}$ = 0.99 in 2009, it can be concluded that the resource is over-exploited, with future catches being highly dependent on incoming recruitment. The continued low abundance of adult fish in the surveyed population and landings indicate a very high exploitation pattern far in excess of those achieving high yields and low risk of fisheries collapse.

- Source of data and methods:

The state of exploitation was assessed for the period 2002-2009 applying the Extended Survivor Analysis (XSA) method (Lowestoft suite; Darby and Flatman, 1994) calibrated with fishery independent survey abundance indices (MEDITS). In addition, a yield-per-recruit (Y/R) analysis was carried out. Both methods were performed from the size composition of trawl landings, transforming length data to ages by slicing (L2AGE program).

Growth parameters (L_{inf}= 85.0; K 0.172; t_0= -0.177; otolith readings), length-weight relationship (a=0.0032, b=3.21) and maturity ogive were taken from the DCF. Data on annual landings and annual distributions of sizes and ages and MEDITS data were also taken from the DCF. Natural mortality vector was estimated using PROBIOM (Caddy and Abella, 1999). The set of parameters used in this assessment is different from that used in the previous analysis of this stock (SGMED 09-02), which corresponded to a fast growth of the species.

Outlook and management advice

SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.
Although the stock is overexploited, it is important to remark than the oscillations found for this species are in agreement with other areas in the Mediterranean and probably caused not only by the fishing effort but also by environmental changes. For this reason, it is important to follow the evolution of this stock, especially because it seems it has started to recover during the last two years.

Short and medium term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries
Exploitation is based on very young age classes, mainly 0 and 1 year old individuals, with immature fish dominating the landings. During last years, the annual landings of this species were around 3,500 tons in the

whole GSA 06 (3,754 t in 2009). According to STECF stock review part II (2007), the total trawl fleet of the whole geographical sub-area 06 (Northern Spain) is made up by 647 boats: on average, 47 TRB, 58 GT and 297 HP. Some of these units (smaller vessels) operate almost exclusively on the continental shelf (targeted at red mullet, octopus, hake and sea breams), others (bigger vessels) operate almost exclusively on the continental slope (targeting decapod crustaceans) and the rest can operate indistinctly on the continental shelf and slope fishing grounds, depending on the season, the weather conditions and also economic factors (e.g. landings price). The percentages of these trawl fleet segments have been estimated around 30, 40 and 30% of the boats, respectively.

In 2009 the trawl fleet consisted of 603 vessels, according to the statistics of the Autonomous Governments of Valence (305 in southern GSA06) and Catalonia (298 in northern GSA 06).

Year	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	
GSA 6 Landings (t)	3850	5187	3770	3286	3462	4497	3269	
Effort (days)	127167	106778	124183	113978	84966	67922	50553	
Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
GSA 6 Landings (t)	3195	3411	3441	3363	3864	3701	3494	3754
Effort (days)	92026	120049	104004	123302	106015	108879	92877	

(2002-2009 landings data taken from DCF; remaining data taken from SGMED-09-02 report)

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (ages 0-2)=	≤0.2
F_{msy} (age range)	
F_{mean} (age range)=	
Z_{msy} (age range)=	
Z_{mean} (age range)=	
B_{pa} (spawning stock)=	≥ 4,000 t
B_{lim} (spawning stock)=	≥ 2,200 t

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 06 can be found in section 5.4 of this report.

Input data were taken from the DCF. Results of this assessment show lower values of F than those presented in the previous assessment of hake in GSA06 (SGMED-09-02 report), where it was shown that F fluctuated around 1.6 ($Fbar_{02}$). The different input data used may explain the differences in the results of the assessments conducted during SGMED-09-02 and SGMED-10-02. The data series used in this assessment is much shorter (2002-2009) than that used in the previous assessment (1995-2008). In any case, results are coincidental in that hake is heavily over-exploited (growth over-fishing), with a high dependence on recruitment.

4.3. Hake in GSA 07

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 07

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the status of the SSB. A slight increase of the total biomass was observed in the recent years (2005-2009). The spawning stock shows no particular trend since 1998.

- State of the juveniles (recruits):

Since 1998, 3 recruitments appear to be above average (1998, 2002 and 2007-2008).

- State of exploitation:

SGMED proposes the referent point $F_{0.1}$= 0.27 as a proxy for F_{msy}. The current F_{ref} is 0.92. SGMED considers that the stock is overexploited and recommends fishing mortality be reduced to the proposed reference point.

- Source of data and methods:

No Spanish data for GSA 7 were provided from the official data call but directly by the expert. No French effort data for GSA 07 were provided for 2009. No significant discards for this species in 2009 were reported (8 tons from the small pelagic fisheries - landings of trawlers are in 2009 around 1633 tons). To perform the XSA, we used data coming from DCF (size distribution of the landings of french and spanish trawlers, French gillnetters and Spanish longliners, landings) for the period 1998-2009. The VPA was tuned using only MEDITS indices (1998-2009). These data were also provided by the data call. We were recommended not to use the other tuning data (French and spanish trawler, Spanish longliner) because of there no standardization.

Before performing the XSA, we calculated Ft using FLEDA (in R). We considered M=0.23 (mean of the vector of natural mortality for both sexes from Probiom). Ft obtained was 0.722.
We run a separable using Ft= 0.722 (Reference age for unit selection: 1, Terminal S: 0.7). We obtained a vector of F from 2009 which was used to perform the XSA.

Outlook and management advice

SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

Hake *(Merluccius merluccius*) is one of the most important demersal target species of the commercial fisheries in the Gulf of Lions (GFCM-GSA07). In this area, hake is exploited by French trawlers, French gillnetters, Spanish trawlers and Spanish long-liners. Around 230 boats are involved in this fishery and, according to official statistics, total annual landings for the period 1998-2009 have oscillated around a mean value of 2160 tons (2260 tons in 2009). The fishing capacity of the GSA 07 has shown in these last 10 years a progressive decrease considering the French trawlers. The number of these trawlers decreased of about 30% on the period.

Most fleets and catches correspond to French trawlers (49 and 70%, respectively). Trawlers catches range between 3 and 92 cm total length (TL), with an average size of 20 cm TL, followed by French gillnetters (~32 and 15% respectively, ranging 13-86 cm TL and average size 39 cm TL), Spanish trawlers (~12 and 8%, respectively, ranging 5-87 cm TL, and average size 25 cm TL), and Spanish long-liners (~7 and 7%, respectively, ranging 23-96 cm TL and average size 54 cm TL). Hake trawlers fishery exploits a highly diversified species assemblage: Striped mullet (*Mullus barbatus*), Red mullet (*Mullus surmuletus*), Angler (*Lophius piscatorius*), Black-bellied angler (*Lophius budegassa*), European conger (Conger conger), Poor-cod (*Trisopterus minutus capelanus*), Fourspotted megrim (*Lepidorhombus boscii*), Soles (*Solea spp.*), horned octopus (*Eledone cirrhosa*), squids (*Illex coindetii*), Gilthead seabream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), Seabreams (*Pagellus spp.*), Blue whiting (*Micromesistius poutassou*), Tub gurnard (*Chelidonichtys lucerna*) are among the most important species in the accompagning species.

French and Spanish landings (t) by year and major gear types, 2002-2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	7	FRA	GNS	DEMSP	50D100	177	248	99	255	299	168	111	287
HKE	7	FRA	LLS	DEMSP	NA	5							
HKE	7	FRA	OTB	DEMSP	40D50	2163	2029	1018	995	1011	1277	1898	1633
HKE	7	SP	OTB			231	206	101	125	116	107	192	258
HKE	7	SP	LLS			146	112	78	101	170	143	97	83
Sum						2722	2595	1296	1476	1596	1695	2298	2261

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age0-5) =	≤0.27
F_{max} (age 1-5) =	
F_{msy} (age range) =	
B_{msy} (spawning stock) =	
B_{pa} (B_{lim}, spawning stock) =	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 07 can be found in section 5.5 of this report.

It's necessary to improve the national statistics on catches and effort for small scale fisheries especially for french gillnetters.

4.4. Hake in GSA 09

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the SSB. From the above reported analyses, SSB in 2009 was likely to amout to 5-10% of the SSB at F_{msy}. STECF SGMED-10-02 underlines that this conclusion could be influenced by the observed exploitation patterns in the surveys and fisheries, which almost exclusively represent the juvenile part of the stock.

- State of the juveniles (recruits):

In recent years recruitment has varied without a clear trend.

- State of exploitation:

SGMED-10-02 recommends $F_{0.1}$=0.2 as limit management reference point consistent with high long term yields. The stock appeared heavily overexploited in 2008 and F needs a consistent reduction from the current F towards the candidate reference points for long term sustainability based on F around $F_{0.1}$ (0.2). However, considering the high productivity in terms of incoming year classes, this stock has the potential to recover quickly if F is reduced towards F_{msy}. The continued lack of older fish in the surveyed population indicates exploitation rates far beyond those considered consistent with high yields and low risk. An improvement of the estimates of catchability of adults is needed to better estimate the stock dynamics and to assess the likely impact of fishing activity on this stock.

- Source of data and methods:

MEDITS survey data were available from 1994. A check of hauls allocation between GSA 9 and 10 needs to be done before calculation of indices from JRC MEDITS database. Landing data for 2009 were not available during SGMED-10-02, while effort data seem not consistent with previous estimates for the GSA. Landings for 2009 were not submitted by the Italian authorities. Due to lack of numbers-at-age or numbers-at-length from the landings the update of the VIT assessment in 2009 was therefore not carried out. Stock parameters are estimated by means of LPUE, SURBA and VIT.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Hake is among the most important component of bottom trawlers targeting a species complex and is the demersal species providing the highest landings and incomes for the GSA 09. The analysis of available information suggests that about 90% of landings of hake are obtained by bottom trawl vessels; the remaining fraction is provided by artisanal vessels using set nets, in particular gillnets. The main trawl fleets of GSA 09 are present in the following continental harbours: Viareggio, Livorno, Porto Santo Stefano (Tuscany), Fiumicino, Terracina, Gaeta (Latium). As concerns fishing activity, the majority of bottom trawlers of GSA 09 operate daily fishing trips with only some vessels staying out for two-three days and especially in summer. Hake fishing grounds comprise all the soft bottoms of continental shelves and the upper part of continental slope. Fishing pressure shows some geographical differences inside the GSA 09 according to the consistency of the fleets and the characteristics of the bottoms. The artisanal fleets, according to the last official data (end of 2006), accounted for 1,309 vessels that operate in several harbours along the continental and insular coasts. Of these, about 50 vessels, mainly located in some harbors of the GSA 09 (e.g. Marina di Campo, Ponza, Porto Santo Stefano), utilize gillnets and target medium and large-sized hakes (larger than 25 cm TL) especially from winter to summer.

Landings (t) by year and major gear types, 2004-2008 as reported through DCF.

Gear	2004	2005	2006	2007	2008
Bottom trawls	553	1054	1180	1025	915
Longlines	4	11	142	16	5
Miscellaneous	40	20	4		
Nets	596	835	1002	712	410
Seines	2		0		
Surrounding nets	0		3		
Totale complessivo	1195	1920	2330	1753	1330

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age1-5)	≤0.2
F_{max} (age 1-5) =	
F_{msy} (age range) =	
B_{msy} (spawning stock) =	
B_{pa} (B_{lim}, spawning stock) =	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 09 can be found in section 5.7 of this report.

GRUND data prior to 1994 should be standardised and used within this assessment.

4.5. Hake in GSA 10

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

- State of the adult abundance and biomass:

Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. However, recent values are among the highest observed since 1994. The Aladym model showed instead that the SSB was continuously decreasing. No precautionary biomass reference points have been proposed for this stock. As a result, SGMED-10-02 is unable to fully evaluate the status of the stock with respect to biomass.

- State of the juvenile (recruits):

Recent recruitment since 2006 appears to be above average, as derived directly from the trawl survey estimates considering as recruits the age 0 group and from the SURBA model analysis.

- State of exploitation:

SGMED 10-02 proposes $F \leq 0.2$ as limit management reference point (basis $F_{0.1}$) consistent with high long term yields. Given the results of the present analysis, the stock appeared to be overexploited in 2006-2008. Regardless of the growth pattern a considerable reduction is necessary to approach the $F_{0.1}$ reference point (Factor; ~70-80% of the current F value, depending on the year) which can be considered in the range 0.16-0.20.

- Source of data and methods:

The data used in the analyses were from trawl surveys (time series of MEDITS and GRUND surveys from 1994 to 2009 and from 1994 to 2006 respectively) and from fisheries. No landings data for 2009 were available from Italian authorities. A check of the hauls allocation between GSA 09 and 10 is needed before the calculation of indices from the JRC MEDITS database.

The analyses on the population were conducted using SURBA, ALADYM and VIT models in a complementary way. Two growth scenarios were tested: Set 1) 'slow' growth: L_∞=97.9 cm, K=0.135, t_0= -0.4; males: L_∞=50.8 cm, K=0.25, t_0= -0.4; length-weight relationship: a=0.00355, b=3.22 for sex combined. Set 2) 'fast' growth: L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship: a=0.00355, b=3.22 for sex combined. Natural mortality vector for the two scenarios were obtained applying the Prodbiom method. Size at first maturity was varying around 32 cm (maturity range 2 cm).

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced also by means of closing areas until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

European hake is mostly targeted by trawlers, but also by small scale fisheries using nets and bottom long-lines. Fishing grounds are located along the coasts of the whole GSA, offshore 50 m depth or 3 miles from the coast. Catches from trawlers are from a depth range between 50-60 and 500 m and hake occurs with other important commercial species as *Illex coindetii*, *M. barbatus*, *P. longirostris*, *Eledone* spp., *Todaropsis eblanae*, *Lophius* spp., *Pagellus* spp., *P. blennoides*, *N. norvegicus*.

Annual landings (t) by fishing technique, 2004-2008.

Somma di LW					YEAR				
AREA	SPECIES	FT_LVL3	FT_LVL4	FT_LVL5	2004	2005	2006	2007	2008
10	HKE	Bottom trawls	OTB	Deep water species			13.558	4.258	2.642
				Demersal species	186.179		97.004	172.701	350.532
				Mixed demersal and deep water species	299.705	611.932	648.723	463.741	147.429
		Longlines	LLD	Large pelagic fish		0.518			1.535
			LLS	Demersal fish	266.362	269.229	287.722	240.192	232.314
		Miscellaneous	Miscellaneous	"	197.794	177.08	8.319		
		Nets	GND	Small pelagic fish	6.595	8.038	11.976	10.643	8.074
			GNS	Demersal species	177.196	293.787	322.681	212.831	310.972
				Small and large pelagic fish				6.992	0.292
			GTR	Demersal species	202.169	124.151	152.068	157.296	67.622
		Seines	SB-SV	Demersal species	1.301				1.424
		Surrounding nets	PS	Small pelagic fish	1.266		2.012		
Total					1338.567	1484.735	1544.063	1268.654	1122.836

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (equilibrium)	≤0.2
F_{max} (age range)	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 10 can be found in section 5.8 of this report.

4.6. Hake in GSA 11

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 11

Most recent state of the stock

- State of the adult abundance and biomass:

Due to the lack of validated landings information, SGMED-10-02 was not in the position to estimate the absolute levels of stock abundance. Survey abundance (n/km²) and biomass (kg/km²) indices do not indicate a significant trend. The stock SSB is more variable over the last decade. No precautionary biomass reference points have been proposed for this stock. As a result, SGMED is unable to fully evaluate the status of the stock with respect to biomass.

- State of the juvenile (recruits):

Due to the lack of validated landings information, SGMED-10-02 was not in the position to estimate the absolute levels of recruitment. Relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2009, with a clear decreasing trend in the last five years.

- State of exploitation:

SGMED-10-02 proposed $F_{0.1} \leq 0.19$ as limit management reference point consistent with high long term yields. Trends in the average fishing mortality over ages 1 to 3 derived from MEDITS surveys ranged from 1.5 to 3.1, with the highest value observed in the last year. SGMED notes that the current F is far in excess of the proposed target reference point $F_{0.1}$. Assuming a similar selection patters of the survey and the commercial fishery, SGMED concludes that the hake stock in GSA 11 is heavily overfished.

- Source of data and methods:

MEDITS survey data were available from 1994 with minor error for 2009 in JRC database that need to be checked, while landing and effort data quality and availability were not satisfying. In particular landings derived from LLS, GNS and GTR seem to be overestimated for the period 2004-2008 and are lacking for 2009. Landings for 2002 and 2003 are not comparable with the other years and appear to be reported in kg rather in metric tons. Landings by length class from italian authorities do not include 2009, while 2008 have been expanded and 2006-2007 have not. Discards have been reported for 2005 and 2006 only. The effort data are lacking for 2008 and 2009, while fishing days seems to be underestimated for OTB in 2005, 2006 and 2007. Moreover different and contradictory version of the same archive increase the perception of poor quality of reported data. The SURBA software program was used to analyse the MEDITS time series and to estimate relative SSB and F. Data coming from DCR (size distribution of landings for trawl) for the period 2006-2007 were used to run stock analyses.

Outlook and management advice

SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

Given the data constraints SGMED-10-03 (13-17 December 2010) will be unable to accomplish short and medium term predictions of stock biomass and catches for 2010 and 2011.

Fisheries

Hake is exploited in all trawlable areas around Sardinia and is one of the most important target species showing the highest landings. According to the scientists' knowledge of the GSA 11 landings of hake comes almost entirely from bottom trawl vessels whereas catches from trammel nets or longlines are negligible. Small hakes are commonly caught from shallow waters about 50 m to 300 m depth, whereas adults reach the maximum depths exploited (800 m). Both small and adults catches coming from a mixed fishery, then in the GSA there is not a specific Hake fishery. The most important by catch species are horned octopus (*Eledone cirrhosa*), squids (*Illex coindetii*), poor cod (*Trisopterus minutus capelanus*) at depths less than 350 m and (*Chlorophtalmus agassizii*), greater forkbeard (*Phycis blennoides*) and deep-water pink shrimp at greater depth (*Parapenaeus longirostris*).

At the end of 2006 the trawl fleet of GSA 11 accounted for 157 vessels (11.7% of the overall Sardinian fishery fleet). The main trawl fleets of GSA 11 are present in the following harbors: Cagliari, Alghero, Porto Torres, La Caletta, Sant'antioco, Oristano, Alghero and Arbatax. The fishing capacity of the GSA trawl fleet has shown in these last 15 years remarkable changes. From 1994 to 2004 a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. In the latest years the effort shows a peak in 2005. In the last five years the total landings of hake of GSA 11 fluctuated between 592 to about 768 tons, with a consistent drop (-25% of the mean) in the last year (2008).

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age 1-5)	≤0.19
F_{max} (age 1-5)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 11 can be found in section 5.9 of this report.

GRUND data should be standardized and used in the assessment. Updated and quality checked landings data are essential to apply other assessment approach such as LCA.

4.7. Hake in GSAs 15 and 16

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 15 and 16

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the spawning stock.

- State of the juvenile (recruits):

MEDITS results indicate that levels of recruitment peaked in 2005-2007, followed by a decline in 2008 and 2009.

- State of exploitation:

SGMED proposes $F_{0.1}$=0.3 as limit management reference point consistent with high long term yields. Results of analyses performed on fisheries dependent as well as fisheries independent data using different modelling approaches gave consistent results. All approaches indicated that fishing mortality is far in excess of sustainable levels, and that *Merluccius merluccius* in GSA 16 was overexploited during the years 2006, 2007 and 2008. The continued low abundance of adult fish in the surveyed population as well as commercial catches similarly indicate very high exploitation patterns far in excess of fishing mortalities consistent with sustainable high yields.

- Source of data and methods:

Data was derived both from indirect (fisheries monitoring) and direct (scientific surveys) sources. Stock status was assessed by using VIT, SURBA (Needle 2003) and non-equilibrium surplus production model. Stock parameters were calculated by taking averages of male and female parameters, which were weighed by sex ratio. In terms of data quality and availability, SGMED-10-02 noted that data from GSA 15 was submitted late. Whilst data from commercial catches declared in GSA 16 are considered representative for the entire area, the lack of scientific survey data from GSA 15 did impact the overall quality of the assessment since the Central Mediterranean hake population is distributed throughout both GSA 15 and GSA 16. SGMED 10-02 further noted the absence of GSA 16 2009 landings data, which meant assessments based on commercial catches could only be carried out for years 2006, 2007 and 2008. Finally, an error in the GSA 16 effort data in terms of KW * Days was noted for otter board trawlers measuring > 24m in length.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Although hake is not a target of a specific fishery such as deep water pink shrimp and striped mullet, it is the third species in terms of biomass of Italian yield in GSA 16. Hake is caught by trawlers in a wide depth range (50-500 m) together with other important species such as *Nephrops norvegicus*, *Parapenaeus* *longirostris*, *Eledone* spp., *Illex coindetii, Todaropsis eblanae*, *Lophius* spp., *Mullus* spp., *Pagellus* spp., *Zeus faber, Raja* spp among others. In 2004-2008, 98.5% of declared catches were caught by demersal otter board trawlers, which is the fleet segment the current assessment is based on. 1.1% of catches were obtained using longlines, and 1.8% using trammel nets. Italian trawling, based in the harbors along the southern coasts of Sicily, operate both in GSA 16 and 15 with exclusion of the Maltese Fishing Management Zone (FMZ). Italian trawlers exert the most of fishing effort and yield more than 90% of hake catches in the entire area. In the late nineties Sicilian trawlers fishing off-shore (15–25 days of trip) had higher discard rates of hake (31% in weight of total catch) than the inshore trawlers (1-2 days trips) (9% in weight). More recent data showed that discarded fraction of undersized hakes by Sicilian trawlers decrease (3.4% in weight in 2008), amounting to about 46 tons in 2008. Overall landings decreased for demersal trawlers measuring >24m in length, but remained stable for trawlers measuring 12-24m in length. The trends in fishing effort of the bottom otter trawl fleet increased from 2004 to 2007 by 32%, but declined again by 25% from 2007 to 2008.

Landings (t) of hake by fishing technique by the Sicilian fleet as recorded under the EU DCF.

	Landings (tonnes)			
Year	Demersal Trawls (OTB)	Longlines (LLS)	Pelagic Trawls (OTM)	Trammel Nets (GTR)
2004	1949	0.1	/	0.0
2005	1720	23.2	/	46.3
2006	1598	22.2	/	6.3
2007	1599	35.7	/	83.4
2008	1367	11.6	0.1	15.9

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age 1-5)	≤0.3
F_{max} (age 1-5)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSAs 15 and 16 can be found in section 5.10 of this report.

GRUND data should be standardized and used in the assessment. Updated and quality checked landings data are essential to apply other assessment approach such as LCA.

4.8. Hake in GSA 17

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 17

Most recent state of the stock

- <u>State of the adult abundance and biomass:</u>

The spawining stock biomass estimated by VPA in the four scenarios ranged from 1,200 to 5,800 tonnes. Without any precautionary biomass reference proposed or agreed, SGMED-10-02 is unable to fully evalute the state of the stock size.

- <u>State of the juvenile (recruits):</u>

The average number of recruits estimated by VPA in the four scenarios ranged from 65 to 200 millions of specimens. SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

- <u>State of exploitation:</u>

SGMED-10-02 proposes the estimated $F_{0.1}$=0.33 as proxy for Fmsy and as a sustainable management reference limit consistent with high long term yields. In the four scenarios, the values of the current F ranges from 0.55 to 0.84 and the values of $F_{0.1}$ from 0.3 to 0.33, thus the stock of hake in GSA17 can be considered overexploited in 2006-2008. Moreover, according to Rochet and Trenkel (2003), it would be safe to avoid F/Z higher than 0.50: the estimated values of F/Z based on the current F in all scenarios were from 0.62 to 0.74. Finally, a meaningful percentage of caught hake has a length below the values of sexual maturity: this is a further reason for caution in managing this stock.

- <u>Source of data and methods:</u>

In the Adriatic, the species is mainly fished with bottom trawl nets, but long-lines and trammel-net are also used. According to the FAO statistics, in the 1980s and 1990s the annual European hake landings in the Adriatic were estimated at 2,000 – 4,000 tonnes, and this species was the most abundant within the demersal fish group. VPA analysis was performed using VIT program using as input catch data the landings at age for the period 2006-2008 from bottom trawl, cause no information were available on age distribution of others gears. Anyway the catches of bottom trawl represents about the 99% of the overall catches. Growth parameters used were those from EC XIV/298/96-EN, (1996; L_{inf}= 85.0; k 0.12; t_0= -0.73). Length-weight relationship data come through the official data call. For the input of maturity at age, data from GSA 18 were used. M Vector by age was estimated using PROBIOM. The terminal F used (0.31) was estimated by Medits data through a Catch Curve analyses of the oldest class ages.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

<u>Short and medium term scenarios:</u>

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

The fisheries for hake are one of the most important in the GSA 17. Fishing grounds mostly correspond to the distribution of the stock (SEC (2002) 1374). On the basis of data collected for Italy through DCR from 2004 to 2008, landings are due mainly to bottom otter trawlers, which account for over 95% of the total. No data are provided in 2009 by the Italian authorities.

Hake landings (tonnes) in GSA 17 by fishing technique, 2004-2008.

	Bottom trawls	Miscellaneous	Nets	Pelagic trawls	Surrounding nets	Traps	Total
2004	3,025.7		18.5	0.6		0.1	3,044.9
2005	3,563.0	0.3	45.4	0.2	0.2		3,609.0
2006	4,339.3	3.2	50.9	2.0			4,395.4
2007	3,736.4		27.6	0.1			3,764.1
2008	3,141.7		35.0				3,176.7

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)	≤0.33
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 17 can be found in section 5.11 of this report.

According to the landings data by length, smallest landed size class is 12 cm and no data on discards were available to SGMED-10-02. Furthermore, data on landings by age were available only for the period 2006-2008, and discrepancies in the size distribution of the landings were noticed. Thus, this assessment should be considered only as preliminary.

4.9. Red mullet in GSA 05

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 05

Most recent state of the stock

- State of the adult abundance and biomass:

Both SB and SSB showed a clear decrease from 2000 to 2003; SB decreased from 75 to 45 tons and SSB from 45 to 25 tons. Subsequently, both parameters remained rather constant or even increased slightly until 2007. However, SB showed a marked decreasing trend between 2007 and 2009, which was also followed by SSB; in both cases the lowest historical values were obtained in the last assessed year. In spite of this, SSB remained constant between 55 and 65% of the SB throughout the entire time series. As no precautionary management reference points are proposed, SGMED cannot fully evaluate the state of the SSB.

- State of the juvenile (recruits):

With the exception of 2001, recruitment remained rather constant between 1.3 and $1.5 \cdot 10^6$ during 2002-2006. Since then, however, the number of recruits has decreased progressively to the point that the lowest historical values were reached during 2008-2009.

- State of exploitation:

SGMED-10-02 proposes $F_{0.1}$=0.31 as limit management reference point consistent with high long term yields. Fishing mortality has ranged between 0.7 and 1.7 during the entire series and it is noticeable the abrupt decrease in 2003 coinciding with the lowest historical landings. Although fishing mortality has decreased progressively from 2004 to 2007, it has increased during the last two years. The vector of fishing mortality by age depictures a typical selection curve and shows that the highest fishing exploitation is suffered by individuals between 2 and 3 years old and also that there is no exploitation of the recruits (age 0). The current F_{ref} (1.0805) is above the Y/R $F_{0.1}$ reference point (0.31), which indicates that red mullet in GSA 5 is subject to overfishing.

- Source of data and methods:

Landings time series from 2000 to 2009 from all fishing ports of Mallorca. Length frequency distributions from on board monthly samplings developed during the entire time series. The biological parameters used for the assessment were the following: 1) growth parameters agreed in the SGMED 09-01 meeting; 2) length-weight relationships obtained from the Spanish National Data Collection; 3) natural mortality at age calculated using the PROBIOM spreadsheet (Abella et al. 1997); and 4) maturity at age obtained from the Spanish National Data Collection in GSA05. Terminal fishing mortality (Ft) was obtained from the catch curve, using the FLEDA package (Jardim & Azevedo, 2004), and adjusted afterwards with a previous VPA followed by a Separable VPA. Finally, the vector of F by age, including the Ft, obtained with this Separable VPA was used as input parameters. The data used for tuning was the abundance (N/km^2) of *M. barbatus* obtained during the MEDITS surveys developed during 2001–2009 around the Balearic Islands. Several subsequent XSA trials were also performed where the age at which catchability (q) is independent of stock size and the age at which q is independent of age were adjusted. The best result was obtained using q independent of stock size for all ages and q independent of age for ages >= 2.

Outlook and management advice

The stock status indicators showed that the resource is overexploited (F_{ref}>$F_{0.1}$). SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated. A part of the catches is under the minimum landing size. In this sense, the improvement of the trawl exploitation patterns imply further increases in potential landings.

Short, medium and long term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

The two species of red mullet inhabiting the Mediterranean, *Mullus surmuletus* and *M. barbatus*, are present in the GSA 5. However, *M. surmuletus* predominates in this area where the species is targeted by both the artisanal and trawl fleet working along the continental shelf. On the contrary, *M. barbatus* is exclusively caught as a by-catch species by trawlers operating mainly on the deep shelf. In the Balearic Islands, *M. surmuletus* and *M. barbatus* represent about 80% and 20% of the total red mullet catches respectively. During the 2000-2009 period the landings of *M. barbatus* from Mallorca have ranged between 10.5 and 27.8 tons.

Landings (t) as submitted to the official DCF data call in 2010, 2002-2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	5	ESP	OTB	DEMSP	40D50	14	11	20	13	11	14	18	12

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (1-5)=	≤0.31
F_{max} (1.5)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

E_{lim} (age range)=	
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 05 can be found in section 5.17 of this report.

4.10. Red mullet in GSA 06

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 06

Most recent state of the stock

- State of the adult abundance and biomass:

SSB (age 1+) has been declining since 2006 and reached the lowest value of the time series in 2009.

- State of the juvenile (recruits):

Recruitment (age 0) has been declining since 2005 and reached in 2009 the lowest value of the time series.

- State of exploitation:

Although imprecisely estimated, SGMED proposed $F_{0.1}$=0.74 for ages 1-3 to be used as a management limit of exploitation. With the F_{ref} being estimated at 1.08, SGMED concludes the stock being subject to overfishing. These results support the status of overexploitation already stated in a previous (2008) assessment conducted in GSA06 by GFCM (www.gfcm.org; reviewed by SGMED 08-04), and also in the analyses conducted by Martín et al. (1999) and Demestre et al. (1997) more than ten years ago.

- Source of data and methods:

All data used in the assessment were collected through DCF and provided during the meeting. MEDITS surveys and official landings and biological data collected within the DCF framework covered the period 2002-2009.

The state of exploitation was assessed by means of a XSA analysis, tuned with standardised CPUE from abundance indices from trawl survey (MEDITS). Tuning is however limited by the fact that MEDITS and landings are poorly correlated. Analysis was carried out applying the Extended Survivor Analysis (XSA) method (Lowestoft suite) over the period 2002-2009. In addition, a yield-per-recruit (Y/R) analysis was applied to the data to estimate $F_{0.1}$ and F_{max}. Input data were the age composition of trawl catches provided by the DCF. Numbers by age for 2009 were missing in the DCF and therefore the annual length distributions of landings in 2009 were transformed to ages using L2Age4.exe (estimated using the numbers by size and the growth parameters). The tuning parameters (MEDITS) were calculated by transforming the MEDITS length distributions to ages using L2Age4.exe.

Growth parameters used were those from GSA 09, since no growth parameters were provided by DCF for red mullet in GSA 06 (L_{inf}= 29.0; k = 0.6, t_0= -0.1). These values are consistent with SGMED 09-01 recommendations, and fit to the length range of the data. Consequently, the parameters of the weight-length relationship were also derived from GSA 09 (a=0.0053 and b=3.12), as well as the maturity ogive (Age 0=0. Age 1+= 1). An M vector was used estimated with PROBIOM (Age 0 = 1.36, Age 1= 0.77, Age 2= 0.66, Age 3= 0.61, Age 4+=0.54).

Outlook and management advice

The stock being subject to overfishing and thus SGMED recommends a reduction in fishing effort of the trawl fleet, particularly during the spawning season (late spring) and/or the recruitment season (early autumn) in the context of a multi-annual management plan taking into account the multi-species landings of the trawl. SGMED is unable to precisely quantify the effort reduction required. The only positive aspect in GSA 06 is that albeit the enforcement of the minimum landing size regulation appeared poorly implemented in the beginning of the 2000s, it has much improved during the last few years (in 2009, only 6% of the specimens were undersized). This aspect should even ameliorate since 1st June 2010, when square-meshed nets of 40 mm at the cod-end or diamond meshed nets of 50 mm will be used. Previous studies already analyzed the positive impact on the stock of a change in the configuration from diamond- to square-mesh on size selectivity of red mullet as well as on other demersal species in the Mediterranean (see e.g. Sala et al

2008; Bahamon et al. 2006). SGMED 08-04 already noted (transition analysis) that an increase in Y/R between 20 and 30% were expected with a change to the square mesh in the cod-end. Therefore the enforcement of this change in the gear selectivity should have a short term negative impact on landings (under the status quo fishing effort) but should benefit the stock productivity in the near future.

Fisheries

No updated information was available to SGMED-10-02. STECF Stock Review 2007 part II stated that red mullet is one of the main target species for the trawl fisheries carried out by around 647 vessels in GSA 06 with an average of 47 TRB, 58 GT and 297 HP. Some of these units (smaller vessels) operate almost exclusively on the continental shelf (targeting among other species red mullet), whilst others (bigger vessels) operate almost exclusively on the continental slope (targeting decapods) and the rest can operate indistinctly on the continental shelf and slope, depending on the season, the weather conditions and also the economic factors (e.g. landings price). The percentage of these trawl fleet segments has been estimated around 30, 40 and 30% of the boats, respectively. According to official data, landings of red mullet increased considerably between the 70s and 1982, and from then a decreasing trend has been observed. In 2009, landings attained the lowest value of the last 8 years (743 tons). From 2002 to 2005, landings were dominated by individuals of age 0 (mostly juveniles) whereas from 2006 till present (2009) landings have been dominated by ages 1+ (adults).

The exploitation of red mullet small individuals (recruitment fishery) occurs since decades (Demestre et al 1997). Spawning takes place in late spring and recruitment to the fishery occurs in early autumn, when juveniles are heavily exploited by trawlers (Sánchez et al. 1995; Martín et al. 1999; Lloret and Lleonart, 2002).

Year	2002	2003	2004	2005	2006	2007	2008	2009
GSA 6 Landings (t)	1159	1004	958	1027	1437	1232	1056	743

Precautionary and target management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (1-3)=	Male and females combined, Y/R analysis= 0.74
F_{msy} (age range)	
F_{mean} (age range)=	
Z_{msy} (age range)=	
Z_{mean} (age range)=	
B_{pa} (spawning stock) =	
B_{lim} (spawning stock) =	

Table of **agreed** precautionary and target management reference points or levels

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 06 can be found in section 5.18 of this report.
From the DCF data files, effort data were not available neither the landings by age in the most recent year (2009). Since the sizes of red mullet discarded are unknown, fishing mortality of small juveniles (those particularly exploited by trawlers during autumn, which is the recruitment period of red mullet in this area; Martín et al., 1999; Sánchez et al 1995; Lloret and Lleonart, 2002) is also unknown. Although trawl is responsible of the major part of the landings (around 80-90% according to Martín et al. 1999), the landings attributed to other gears, basically trammel nets, should also be reported and included in the assessment.

4.11. Red mullet in GSA 07

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 07

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed precautionary and limit reference points SGMED is unable to fully evaluate the status of the stock of red mullet in GSA 07. Variation in SSB appears without any praticular trend. However, the recent survey abundance and biomass indices since 2007 appear high but are subject to high uncertainty.

- State of the juvenile (recruits):

Variation in recruitment appears without any particular trend.

- State of exploitation:

SGMED-10-02 proposes $F_{0.1}$=0.5 as limit management reference point for exploitation consistent with high long term yield (F_{msy} proxy). Accordingly SGMED concludes that the stock of red mullet in GSA 07 is subject to overfishing. The 2009 estimate of fishing mortality suggest an effort reduction of around 20% for all fleets to achieve this management goal.

- Source of data and methods:

In terms of data quality and availability, no problem was identified during this SGMED-10-02. Because of the time series is short, we performed a LCA using the VIT software (Lleonart and Salat, 1994). SGMED-10-02 recommended performing both an LCA (VIT) for each individual year (2004-2009) together with a mean pseudo-cohort on the entire period. Ft was estimated using Fleda (Ft=0.526). Yield per recruit analysis was used for the estimation of F_{max} and $F_{0.1}$. Biological parameters used are in the following tables:

Outlook and management advice

SGMED-10-02 recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Based on the biological reference points calculated using VIT results on the mean pseudocohort, fishing mortality should be reduced by 30 and 50% to reach maximum biomass production and $F_{0.1}$ target levels respectively.

Short, medium and long term scenarios:

To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

Red mullet (*Mullus barbatus*) is exploited in the Gulf of Lions (GFCM-GSA07) both by French and Spanish trawlers. Around 120 boats are involved in this fishery. According to official statistics, total annual landings for the period 2004-2009 have oscillated around a mean value of 193 tons. Most boats and catches correspond to the French trawling fleet (77% and 86% respectively), for Spanish trawling fleets it is respectively of 23 % and 14 %. In French and Spanish landings, modal lengths are 13 and 14 cm, respectively.

In GSA 07, the trawl fishery is a multi-specific fishery. In addition to *M. barbatus*, the following species can be considered as important in landings, *Merluccius merluccius, Lophius sp., Pagellus sp., Trachurus sp., Mullus surmuletus, Octopus vulgaris, Eledone sp., Scyliorhinus canicula, Trachinus sp., Triglidae, Scorpaena sp*.

Length at first capture is about 7 cm. Catch is mainly composed by individuals of age 0 and 1 while the oldest age class (5+ group) is poorly represented. Catch rates decreased a little along the analysed period. The number of French boats decreased also of about 30 % on the period.

Annual landings (in tons) of otter trawlers in GSA 07 for the French (FRA) and Spanish (ESP) fleets.

COUNTRY	2002	2003	2004	2005	2006	2007	2008	2009
FRA	163	204	151	148	183	172	111	120
ESP	16	17	26	28	33	37	21	26

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)=	≤0.5
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

E_{lim} (age range)=	
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 07 can be found in section 5.19 of this report.

4.12. Red mullet in GSA 09

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

- <u>State of the adult abundance and biomass:</u>

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the SSB. The index of stock abundance from GRUND survey shows high variability throughout the time series, but no trend is observed. The index of abundance from MEDITS surveys, which approximates a spawning stock biomass index (i.e. mostly mature fish), does not show any trend from 1994 to 2009. Wide fluctuations are observed.

- <u>State of the juvenile (recruits):</u>

Recruitment has slightly increased, especially in the most recent years.

- <u>State of exploitation:</u>

SGMED proposes F_{MSY}=0.64 as limit management reference point for exploitation consistent with high long term yields. The estimate of the current fishing mortality F_{2009} of 0.73 (derived from ASPIC) is higher than the value considered as limit reference point (F_{MSY}=0.64) and to the value derived from the yield-per-recruit analysis ($F_{0.1}$ =0.49). SGMED classifies the stock of red mullet in GSA 09 as subject to overfishing. SGMED recommends to reduce fishing effort of all fleets by about 12% to reach the management reference point. The size of first capture is too low and an increase in yield can be expected in the case of a reduction of fishing effort and through the use of more selective gears. It is advisable to avoid illegal fishing within the 3 miles as well as the landing of undersized individuals in order to reduce fishing pressure on juveniles.

- <u>Source of data and methods:</u>

The available data from both fisheries dependent and fisheries independent sources available is considered good enough in order to perform a reliable assessment of the stock. However, the species dynamics (fast growth, presence of a reduced number of cohorts, the lacking of a good knowledge on the relationship stock/recruitment, the difficulties of ageing, the lacking of a long time series of data on demographic structure of the commercial catches) make difficult the use of most of the age-based traditional approaches of stock assessment.
Landings from 2009 were not submitted by the Italian authorities. The stock is assessed by a stock production model.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level F_{MSY}, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

<u>Short and medium term scenarios:</u>
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

The species is caught as a part of a species mix that constitutes the target of the trawlers operating near shore. The main species caught in GSA 09 are *Squilla mantis, Sepia officinalis, Trigla lucerna, Merluccius merluccius, Mullus barbatus, Gobius niger.* The species is mainly caught in late summer-beginnings of autumn, when juveniles are highly concentrated near shore. Length of first capture is of about 7 cm. Catch is mainly composed by age 0 individuals while the older age classes are poorly represented in the catch. Catch rates increased along the analysed period and considering that no dramatic changes occurred on effort allocation nor on other aspects of fishing behaviour in the analysed years, this increase has to be attributed to an enhancement in biomass. Even if catch within the coastal 3 miles stripe is forbidden, illegal fishing do occur considering the high value that small-sized individuals have in the area.

Annual landings (t) by fishing technique as reported through the DCF data call in 2009.

YEAR	Bottom trawls	Nets	Total catch (Tons)
2004	521.1	59.9	583.2
2005	684.0	30.8	714.9
2006	1033.2	16.4	1050.1
2007	1087.4	8.6	1096.0
2008	716.3	11.2	727.4

Fisheries management reference points or levels

Table of **proposed** precautionary and target management reference points or levels

$F_{0.1}$ (age range) =	
F_{max} (age range) =	
F_{msy} (age range) =	≤0.64
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of **agreed** precautionary and target management reference points or levels

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 09 can be found in section 5.21 of this report.

The issue of unit stocks definition inside the GSA 09 still remains unsolved. In fact, the GSA 09 is divided in two portions, separated by the geographic barrier represented by the Elba island, with the northern portion located in the Ligurian Sea, and the southern one in the Tyrrhenian sea. Considering the sedentary behaviour of the species, that only shows ontogenetic migrations from the shore towards deeper waters, it is likely that the status of the stock in relatively small areas along the coast, will mainly depend on the fishing pressure exerted on them by the local fleets, and will not be influenced by what happens in neighboring areas, exploited at different rates by other fleets. The pooling of the data coming from heterogeneous sub-areas characterized by different levels of abundance and demographic structure, can lead to uncertainty in the definition of the status of the stocks, and such merging may produce a wrong perception of the real status of the stocks and advice, and may lead to a worse utilization of the potential productivity of the resources.

4.13. Red mullet in GSA 10

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

- <u>State of the adult abundance and biomass:</u>

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the SSB. However, survey indices indicate a variable pattern of biomass with the recent values amongst the lowest observed, except for 2007.

- <u>State of the juvenile (recruits):</u>

In 2007 and 2009 the MEDITS surveys indicated abundant recruits.

- <u>State of exploitation:</u>

SGMED-10-02 proposes $F_{0.1}$=0.4 as limit management reference point consistent with high long term yields. Thus, given the results of the present analysis (F2006=0.67, F2007=0.94, F 2008=0.77), the stock appeared to have been subject to overfishing during 2006-2008. Assuming status quo in 2009 and given the 2008 situation, a reduction of F of about 40% would be necessary. This advice will be updated at the next SGMED using the data of 2009.

- <u>Source of data and methods:</u>

The data used in the analyses were from trawl surveys (time series of MEDITS and GRUND surveys from 1994 to 2009 and from 1994 to 2006 respectively) and from fisheries. Landings from 2009 were not submitted by the Italian authorities. Due to lack of numbers-at-age or numbers-at-length from the landings the update of the VIT assessment in 2009 was therefore not carried out. The most updated series from trawl survey was up to 2009. A check of the hauls allocation between GSA 9 and 10 is needed before the calculation of indices from the JRC MEDITS database. All other data available at SGMED-10-02 have been used. Information from GRUND surveys and studies on nursery in the GSA have also been included. Management reference points were estimated by a YpR analysis.

The stock is assessed by a VPA (VIT) using the pseudohort approach for each year (2006, 2007, 2008). A sex combined analysis was carried out. Regarding growth parameters the set L_∞=26 cm k=0.42 t_0= -0.4 was re-parameterized to the following equivalent set: L_∞=28 cm k=0.4 t_0= -0.4, given the presence of individuals with length higher than 26 cm. The length-weight relationship parameters were: a=0.0103; b=3.0246. A constant natural mortality M (Alagaraja) = 0.61 was adopted, because this value was close to 0.70, an estimate reported for a very slightly exploited area in the Castellammare Gulf (northern Sicily coasts) within the GSA. The setting of the proportion of mature females was 0.16 at age 0, 0.92 at age 1 and 1 at age 2. Management reference points were estimated by a YpR analysis.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced also by means of closing areas until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

<u>Short and medium term scenarios:</u>

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Red mullet is an important species in the area, targeted by trawlers and small scale fisheries using mainly gillnet and trammel nets. Fishing grounds are located along the coasts of the whole GSA, offshore around 50 m depth or 3 miles from the coast. Available landing data colleted under the DCF framework range from 524 tons of 2004 to 314 tons in 2008, the latter being the lowest value registered. Most part of the landings of red mullet were from trawlers up to 2006, while since 2007 the level of catches of trawlers is similar to that of the other métier grouped together, to which the maximum contribution is given by gillnet (GNS) and trammel net (GTR). In 2008 the catches of both métier are decreasing.

Annual landings by major fishing techniques in tons for red mullet in the GSA10 (2004-2008).

Somma di LW			FT_LVL4								
SPECIES	AREA	YEAR	miscellanea	GND	GNS	GTR	LLS	OTB	PS	SB-SV	Total
MUT	10	2004	9.801		15.772	96.044	0.58	400.366	0.037	1.773	524.373
		2005	13.533	0.02	24.873	102.202	25.771	254.975			421.374
		2006	0.553		34.51	68.246		289.704			393.013
		2007			24.433	212.208		265.23			501.871
		2008	0.091	0.043	7.185	125.371		182.268			314.958

Fisheries management reference points or levels

Table of **proposed** precautionary and target management reference points or levels

$F_{0.1}$ (age range) =	≤ 0.4
F_{max} (age range) =	
F_{msy} (age range) =	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of **agreed** precautionary and target management reference points or levels

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 10 can be found in section 5.22 of this report.

4.14. Red mullet in GSA 11

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 11

Most recent state of the stock

- State of the adult abundance and biomass:

SGMED could not estimate the absolute levels of stock abundance. MEDITS survey abundance (n/km²) and biomass (kg/km²) indices which should be considered as a proxy of the spawning stock biomass, show high variability throughout the time series. Two peaks of SSB are detected in 1999 and 2007. SGMED is unable to fully evaluate the status of the SSB in the absence of precautionary management reference points.

- State of the juvenile (recruits):

SGMED is unable to provide any scientific advice of the state of recruitment given the preliminary state of the data and analyses.

- State of exploitation:

SGMED proposes $F_{0.1}$=0.32 of ages 1-3 as limit management reference point consistent with high long term yields. Assuming a similar selection patters of the survey and the commercial fishery (SURBA results) the stock of red mullet in GSA 11 is considered overexploited until 2008.

- Source of data and methods:

Landings data from 2009 were not submitted by the Italian authorities. The lacking of a good and long time series of landings and the absence of landing data by length/age data for the small scale fishery make difficult to perform reliable assessments using the traditional methods. Moreover is clear that DCR DCF data report underestimated landings by the artisanal fishery (LLS, GNS and GTR) because the magnitude of effort is 5 time more than the effort of OTB, while catches are less than 5% of the total. Finally the update of some approaches was not possible because landings from 2009 were not submitted to SGMED. All this highlight the lack of checking procedure of the official data as well as the need to improve the sampling design or the survey collection of commercial catches.

The availability and quality of survey data (MEDITS) was appropriate. Due to the fact that the survey has been generally carried out in late spring and did sample the bulk of the recruitment of the species, the assessment of the recruits from the SURBA analysis is not presented. The use of other survey results (GRUND) should help further to update the information and should be encouranged.

The present assessment was derived by both indirect and direct data. By using VIT and SURBA the status stock was assessed considering the same set of parameters reported below. Vectors of natural mortality calculated from ProdBiom were used. Finally the Yield per Recruit (Y/R) Analysis was performed by means of the Yield software.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Red mullet is exploited in all trawlable areas around Sardinia and is one of the most important target species showing the highest landings on shelf bottoms, together with the cephalopod *Octopus vulgaris*. According to the scientist's knowledge of the GSA 11 landings of red mullet comes both from bottom trawl vessels and small artisanal fishery. Commonly small mullets are caught at around 50 m of depth where show high dense paches, whereas adults are caught at greater depths where are less concentrate. Both small and adults catches coming from a mixed fishery, then in the GSA there is not a specific fishery target on red mullet. At the end of 2006 the trawl fleet of GSA 11 accounted for 157 vessels (11.7% of the overall Sardinian fishery fleet). The main trawl fleets of GSA 11 are present in the following harbours: Cagliari, Alghero, Porto Torres, La Caletta, Sant'antioco, Oristano, Alghero and Arbatax. The fishing capacity of the GSA trawl fleet has shown in these last 15 years remarkable changes. From 1994 to 2004 a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. In the latest years the effort show a peak in 2005. In the last five years the total landings of red mullet of GSA 11 fluctuated between 262 to about 354 tons, with a consistent drop (-25% of the 5 years mean) in the last year.

Annual landings (t) by fishing technique in GSA 11, 2002-2008 as reported through DCF.

FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DTS	38	253					
FPO						3	1
FYK						5	1
GNS			3				
GTR			11	13	13	0	1
OTB			333	253	249	346	263
PGP	0						
PMP	77	68					
total landings (all gears)	115	321	347	266	262	354	266

Fisheries management reference points or levels

Table of **proposed** precautionary and target management reference points or levels

$F_{0.1}$ (1-3) =	≤0.32
F_{max} (age range) =	
F_{msy} (age range) =	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of **agreed** precautionary and target management reference points or levels

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 11 can be found in section 5.23 of this report.

4.15. Red mullet in GSA 25

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 25

Most recent state of the stock

Due to data constraints SGMED-10-02 did not update the stock assessment conducted in 2009 by SGMED-09-02. This section reiterates the findings in 2009 in order to facilitate regional overviews of stocks and fisheries' status and contributes to improved consistency regarding the scientific advice.

- <u>State of the adult abundance and biomass:</u>

In the absence of proposed or agreed precautionary reference points SGMED 10-02 is unable to fully evaluate the status of the spawning stock size. In the current stock assessment no trend in the spawning stock biomass is evident.

- <u>State of the juvenile (recruits):</u>

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment as no trend in recruitment is evident.

- <u>State of exploitation:</u>

SGMED recommends $F_{0.1}$ of ages 1-3=0.22 as an approximation of F_{msy} and thus as the limit management reference of exploitation consistent with high long term yields. The estimated reference points of $F_{0.1}$ (0.22) and F_{max} (0.34), in relation with the estimated value of $F_{bar\ (1\text{-}3)}$ (=0.84), sugggest an overexploitation state of the stock in 2005 to 2008. SGMED-10-02 recommends a reduction in fishing effort of the relevant fleets until sustainable levels of fishing effort are achieved. This shoud be done by means of a multi-annual management plan taking into account mixed fisheries implications.

- <u>Source of data and methods:</u>

The present assessment was performed by means of VPA analysis, using a mean pseudo-cohort from catch-at-age data for the period of 2005-2008. A Yield per Recruit (Y/R) Analysis was also performed for the estimation of F_{max} and $F_{0.1}$. The VIT software (Lleonart and Salat, 1992) was used for both analyses. Catch-at-age data derived from landings for each fishing gear exploiting the stock (bottom otter trawl and trammel net), and discards data from bottom otter trawl.
An M vector was used as estimated by PROBIOM. The biological data used were collected within the framework of the Cyprus National Data Collection Programme and submitted under the 2009 Spring Official EC Data Call. No fisheries data for 2009 were submitted by Cyprus through the official DCF data call in 2010.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

<u>Short and medium term scenarios:</u>
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Red mullet in GSA 25 is exploited with other demersal species by the bottom otter trawlers and the artisanal fleet using trammel nets. The main species caught with *M. barbatus* are: *Spicara* spp. (mostly *S. smaris*), *Boops boops*, *M. surmuletus*, *Pagellus erythrinus* and cephalopods (*Octopus vulgaris*, *Loligo vulgaris* and *Sepia officinalis*). The artisanal (inshore) fishery catches also relatively large quantities of *Diplodus* spp, *Sparisoma cretense* and *Siganus* spp. The average percentage of *M. barbatus* in the overall landings of the bottom trawl and artisanal fishery, for the period 2005-2008, was 7% and 2% respectively.

Landings (t) as reported throught the official DCF data call in 2010. No landings in 2009 were reported by Cyprus.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	25	CYP	GTR	DEMSP					25	18	25	13	
MUT	25	CYP	OTB	DEMSP					18	16	23	20	
Sum									43	34	48	33	

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (1-3)=	≤0.22
F_{max} (1-3)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of **agreed** precautionary and target management reference points or levels

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 25 can be found in section 5.30 of this report.

4.16. Pink shrimp in GSA 05

Species common name:	Deepwater pink shrimp
Species scientific name:	*Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s):	GSA 05

Most recent state of the stock

- State of the adult abundance and biomass:

SSB showed a progressive decreasing trend throughout the series; the number of tons decreased from 45 tons in 2001 to less than 5 tons in 2005-2007. However, SSB has slightly increased in 2008 and 2009. In the absence of proposed or agreed precautionary management reference points SGMED is unable to fully evaluate the state of the SSB.

- State of the juvenile (recruits):

Recruitment showed a constant value for the first two years of the series (around 6.5 millions) and a significant decrease in 2003. Recruitment continued to be very low during the following years. However, recent recruitment in 2008 and 2009 has increased slightly.

- State of exploitation:

SGMED proposed $F_{0.1}$=0.31 as limit management reference point for exploitation consistent with high long term yields. Fishing mortality showed oscillations during the entire data series, with the maximum values in 2003 and minimum in 2008. The vector of fishing mortality by age depictures a typical selection curve and shows that the highest fishing exploitation is suffered by 1-year-old individuals and also that the exploitation of the recruits (age 0) is very low. The F_{ref} (0.82) exceeds the Y/R $F_{0.1}$ reference point (0.31), which indicates that pink shrimp in GSA 05 is overexploited.

Although the stock is overexploited, it is important to remark than the oscillations found for this species are in agreement with other areas of the Mediterranean and probably caused not only by fishing mortality but also by environmental changes.

- Source of data and methods:

Landings time series from 2001 to 2009 from the bottom trawl fleet of Mallorca. Length frequency distributions from monthly on board samplings developed between 2001 and 2009. The biological parameters used for the assessment come from previous studies developed in GSA 05 (Guijarro et al., 2009). Natural mortality at age was calculated using PROBIOM spreadsheet (Abella et al., 1997). Terminal fishing mortality (Ft) was obtained from the catch curve, using the FLEDA package (Jardim & Azevedo, 2004). The stock is assessed by applying the XSA analysis.

Outlook and management advice

SGMED recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed $F_{0.1}$ level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

In the Balearic Islands (GSA 05), commercial trawlers employ up to four different fishing tactics (Palmer *et al.,* 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Guijarro & Massutí 2006; Ordines *et al*., 2006). Vessels mainly target striped red mullet (*Mullus sumuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered monospecific. The pink shrimp is caught as a by-catch in the upper slope.

Landings of pink shrimp (in tons, trawling) in the GSA 05 as reported through the official DCF data call 2010, from 2002 to 2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	5	ESP	OTB	DEMSP	40D50	36	22	6	2	1	1	3	6

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)=	≤0.31
F_{msy} (age range)=	
F_{mean} (age range)=	
Z_{msy} (age range)=	
Z_{mean} (age range)=	
B_{pa} (spawning stock) =	
B_{lim} (spawning stock =	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (spawning stock) =	

Comments on the assessment

The detailed assessment of pink shrimp in GSA 05 can be found in section 5.32 of this report.

4.17. Pink shrimp in GSA 06

Species common name:	Deepwater pink shrimp
Species scientific name:	*Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s):	GSA 06

Most recent state of the stock

Due to data constraints SGMED-10-02 did not update the stock assessment conducted in 2009 by SGMED-09-02. This section reiterates the findings in 2009 in order to facilitate regional overviews of stocks and fisheries' status and contributes to improved consistency regarding the scientific advice.

- State of the adult abundance and biomass:

Since 2002, SSB, with an average for the whole period of 342 tons, declined rapidly and continuously to the lowest value observed in 2008 (111 mt) which represents only 8% of that observed in 2002. SGMED notes that the MEDITS survey abundance index shows a very high peak in abundance in the 1999-2001 period, which represents the start of the assessment period. Prior to 1999, abundance levels were comparable to those seen in the 2002-2008 period. However, the 2009 indices of stock size reveal a significant increase. SGMED cannot evaluate the state of the spawning stock relative to managemen reference points, as these have not been proposed or defined.

- State of the juvenile (recruits):

Recruits (aged 0 individuals) were estimated to have declined from 2002 to 2005 in the same pattern as SSB and continued to be very low in 2006-2007. However, in 2008, recruitment increased significantly and appears to be at the level of the 2003 value. Such increased recruitment seem to have contributed to some recovery of the stock in short time as indicated by the survey results in 2009.

- State of exploitation:

Fishing mortality over ages 2-5 displays a high variation with an average value of 0.5. SGMED 10-02 is unable to fully evaluate the exploitation status as no limit management reference points consistent with high long term yields have been estimated.
F and effort should be kept at a low level to allow any strong future recruitments to rebuild the stock. SGMED recommends a recovery plan to be established for this stock that takes into account the mixed species nature of the fishery.

- Source of data and methods:

The state of exploitation was assessed for the period 2002-2008 by means of a VPA Separable, tuned with standardised CPUE from abundance indices from trawl survey (MEDITS). Analysis was carried out applying the Extended Survivor Analysis (XSA) method (Lowestoft suite; Darby and Flatman, 1994) over the period 2002-2008.

The parameters of the size-weight relationship used in this assessment (García Rodriguez et al., 2009) are similar to those calculated by other authors (Ribeiro-Cascalho & Arrobas, 1987; Sobrino, 1998; Tosunoglu *et al*., 2007). The estimates made for the VBGF parameters (García Rodriguez *et al*., 2009) show that, although the L_∞ values were similar, the values for the growth rate (K) calculated in this study are lower than those presented by other authors both for the Mediterranean (Ardizzone *et al.*, 1990; D'Ongia *et al*., 1998) and for the Atlantic (Ribeiro-Cascalho, 1988; Sobrino, 1998), The size composition of commercial landings were obtained by monthly length samplings carried out both in one of the ports (Santa Pola) as well as on board samplings, during the 2002-2008 period. Landings and effort data were obtained combining different sources, such as Official Landings provided by Autonomous Community, and from the Information and Sampling Network of the Spanish Oceanographic Institute (IEO).

Outlook and management advice

Assuming a status quo fishing in 2009 SGMED 10-02 reiterates its recommendation to keep F and effort at a low level to allow any strong future recruitments to rebuild the stock. SGMED recommends a recovery plan to be established for this stock that takes into account the mixed species nature of the fishery. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Deep-water pink shrimp (*Parapenaeus longirostris*) is one of the most important crustacean species for the trawl fisheries developed along the GFCM geographical sub-area Northern Spain (GSA 06). This resource is an important component of commercial landings in some ports of the Mediterranean Northern Spain and occasionally target species of the trawl fleet, composed by around 600 vessels, and especially by 260 vessels which operate on the upper slope. During the last years, a sharp increase in landings was observed, starting in 1998 and reaching the maximum value in 2000, followed by a decreasing trend during the period 2001-2008. In 2008 the annual landings of this species amounts 33 tons in the whole area, which it has been the lowest value of the historical series.

Fishing effort has reduced from 50,000 days in 2000 to 13,000 in 2006, with a slight increase in 2007 and 2008 to 18,000. SGMED notes that the fishing effort only includes vessels that have landed pink shrimp in the given years.

Annual landings (t) of deep-water pink shrimp by fishing technique in GSA 06 as reported throught the official DCF data call in 2010.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	6	ESP	OTB	DEMSP	40D50	380	190	117	63	49	41	33	54

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)=	
F_{msy} (age range)=	
F_{mean} (age range)=	
Z_{msy} (age range)=	
Z_{mean} (age range)=	
B_{pa} (spawning stock) =	
B_{lim} (spawning stock =	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (spawning stock) =	

Comments on the assessment

The detailed assessment of pink shrimp GSA 06 can be found in section 5.33 of this report.

4.18. Pink shrimp in GSA 09

Species common name:	Deepwater pink shrimp
Species scientific name:	*Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

- State of the adult abundance and biomass:

SSB showed an increasing trend during the last 13 years with the highest value in the last year. As no precautionary level for the stock of deep-sea pink shrimp in GSA 09 is proposed or agreed, SGMED cannot evaluate the stock status in relation the precautionary approach.

- State of the juveniles (recruits):

Relative indices for age 1+ from survey data indicated a general increasing trend since 1994 with three main recruitment peaks in 1999, 2005 and 2009. In 2007 recruitment estimated by GRUND survey (age 0) was 61% of the short term average (2004-06). In 2009 recruitment at age 1 (MEDITS) was 180% of the short term average (2005-07). VIT estimates for 2006-2008 showed a reduced recruitment in 2007.

- State of exploitation:

SGMED proposes $F_{0.1}$=0.7 as limit management reference point consistent with high long term yields. According to the F estimates obtained using trawl surveys indices (GRUND and MEDITS) with SURBA, F_{curr} was in most of the years above the average and maximum estimated $F_{0.1}$ values. In this case, the stock would not appear to be able to sustain the current level of fishing effort in the GSA 09 and thus the stock is considered overexploited using survey data estimates.. A different picture comes from the F estimates through LCA on the last three years of landing data. F_{1-3} was between 0.5 and 0.6 for the period 2006-2008, little below the estimated reference value of $F_{0.1}$=0.7. SGMED advice relies on the LCA and considers the stock has been harvested sustainably consistent with high long term yields in 2006-2008. It is important to consider that this stock could be strongly driven by environmental and ecological factors (e.g. water temperature, predatory release effect) that can make difficult to evaluate the effect of fishing on the stock.

- Source of data and methods:

Time series of survey data were used (MEDITS: 1994-2008; GRUND: 1994-2007) to investigate trends in abundance and F with SURBA. Length cohort analysis was used on 2006 and 2007 DCR data. SURBA and VIT analyses were conducted to estimate stock parameters. Medits survey data were available from 1994. A check of hauls allocation between GSA 9 and 10 needs to be done before calculation of indices from JRC MEDITS database. Landing data for 2009 were not available during SGMED-010-02, while effort data seem not consistent with previous estimates for the GSA. Due to lack of numbers-at-age or numbers-at-length from the landings the update of the assessment in 2009 was therefore not carried out.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

The species is exploited by trawl fleet mostly on muddy bottoms from 150 to 500 m depth. Annual trawl landings increased from 160 tons in 2002 to 462 tons in 2006, decreasing to 217 tons in 2007 and 254 tons in 2008.

Annual landings (t) by fishing technique in GSA 09 as provided through the official DCF data call 2010.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	9	ITA						0					
DPS	9	ITA	GNS	DEMSP				4			2	1	
DPS	9	ITA	GTR	DEMSP				4	1				
DPS	9	ITA	OTB	DEMSP				155	42	55	90	187	
DPS	9	ITA	OTB	DWSP								0	
DPS	9	ITA	OTB	MDDWSP				212	388	407	125	66	
DPS	9	ITA	PS	SPF				0					
Sum								375	431	462	217	254	

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (1-3) =	≤0.7
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of pink shrimp GSA 09 can be found in section 5.34 of this report.

4.19. Pink shrimp in GSA 10

Species common name:	Deepwater pink shrimp
Species scientific name:	*Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management references, SGMED-10-02 is unable to fully evaluate the status of SSB. Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. MEDITS indices indicate a sharp decrease from 2006 to 2007 and then a slight increase. GRUND data showed a recent decrease of abundance and biomass from 2005 to 2006 after a rising phase.

- State of the juveniles (recruits):

Recruitment estimates from GRUND surveys showed a decrease in abundance from 2005 to 2006 after a rising phase from 2002 to 2005.

- State of exploitation:

SGMED-10-02 proposes $F \leq 0.65$ as limit management reference point (basis $F_{0.1}$) of exploitation consistent with high long term yield. Given the results of the present analysis, the stock is considered overexploited during the period 2006-2008. SGMED recommends the relevant fleets' effort to be reduced to reach the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan.

- Source of data and methods:

Landings from 2009 were not submitted by the Italian authorities. Due to lack of numbers-at-age or numbers-at-length from the landings the update of the VIT assessment in 2009 was therefore not carried out.. All other data available at SGMED 02 10 have been used. The most updated series from trawl survey terminates in 2009. A check of hauls allocation between GSA 9 and 10 needs to be done before calculation of indices from JRC MEDITS database. Data on maturity and growth have also been used. Information from GRUND surveys and studies on nursery in the GSA have also been included.

The analyses were conducted using VIT and YIELD software. The following growth parameters were used to split the LFD for the VIT age-class analyses; females: $CL_\infty = 4.6$ cm, K= 0.575, t_0= -0.2; males: $CL_\infty = 4$ cm, K= 0.68, t_0= -0.25. Since YIELD software uses only specimens total lengths data for the analyses, growth parameters and length-weight relationship coefficients were converted to the following equation: $TL_\infty = 20.77$ cm, K= 0.575, t_0= -0.23, a= 0.0178, b= 2.5423. Constant natural mortality M (Alagaraja) = 0.9 and a constant recruitment of 182 million individuals were assumed (average recruitment estimated by VIT during 2006-2008) to paramterize YIELD software. Management reference points were estimated by an YpR analysis.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced also by means of closing areas until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

The pink shrimp is only targeted by trawlers and fishing grounds are located offshore 50 m depth, on the continental shelf and slope of the whole GSA. The pink shrimp occurs mainly with *M. merluccius*, *M. barbatus*, *Eledone cirrhosa*, *Illex coindetii* and *Todaropsis eblanae, N. norvegicus*, *P. blennoides*, depending on depth and area.

The catches of the species raised from 2004 to 2006 when 1089 tons were recorded and then declined to 400 tons in 2008, lower than in 2004 (552 tons).

Annual landings (t) by gear type, 2004-2008.

Somma di LW			FT_LVL4									
SPECIES	AREA	YEAR	"	GND	GNS	GTR	LLD	LLS	OTB	PS	SB-SV	Totale complessivo
DPS	10	2004	0.206		2.87	2.539		0.624	544.24	1.261	0.158	551.894
		2005	0.017	0.047	5.876	0.416	0.574	26.078	742.74			775.75
		2006							1087.7	1.042		1088.785
		2007							534.29			534.289
		2008			0.126				400.21			400.333

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)=	≤0.65
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of pink shrimp GSA 10 can be found in section 5.35 of this report.

4.20. Pink shrimp in GSAs 15 and 16

Species common name:	Deepwater pink shrimp
Species scientific name:	*Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s):	GSA 15 and 16

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points SGMED is unable to fully evaluate the state of the SSB. According to VIT analysis, absolute estimations of SSB (combined sex) were 3,223 t in 2006, 1,920 t in 2007 and 1,580 t in 2008. Recent MEDITS indices in 2009 indicate a significant stock recovery in both GSAs 15 and 16.

- State of the juveniles (recruits):

The estimates of absolute recruitment in millions of individuals (11-12 mm CL) from VIT analysis in 2006-2008 were 2,417 in 2006, 2,098 in 2007 and 2,061 in 2008. The time series of recruitment indices from trawl surveys (individuals smaller than 16 mm CL) showed a peak in 2004 (1,802 recruits per km2) in the spring trawl surveys, and in 2005 (1,286 recruits per km2) for the autumn surveys. The mean indices over the time series were 341 ± 463 in spring and 258 ± 306 in autumn. The spring indices in the last three years (2007-2009) were lower than the mean, whereas the only value available for the autumn series (2008) was higher than the corresponding mean.

- State of exploitation:

SGMED proposes $F_{0.1}$ranging between 0.62 (median of VIT analyses) and 0.72 (Yield and Beverton and Holt estimator) as limit management reference point for exploitation consistent with high long term yield. The stock of deep water pink shrimp in the Northern sector of the Strait of Sicily is considered overfished in 2006-2008 as the current fishing mortality is higher than $F_{0.1}$ and F_{max} according to the VIT analyses, and higher than F0.1 and close to Fmax according to trawl surveys data. SGMED recommends an overall reduction in F and effort of ranging between 50 and 70% in order to achieve the proposed management reference point.

- Source of data and methods:

Data was derived both from indirect (fisheries monitoring) and direct (scientific surveys) sources. Stock status was assessed by using a Yield and Spawning Stock Biomass per Recruit analysis with the VIT and Yield packages. Analyses were based length frequency distributions of combined sexes. Current F was assessed using a steady state VPA with VIT by length on LFD of 2006, 2007 and 2008 landings. The stock parameters and vector (maturity by size) were obtained by weighting values by size with the abundance of each sex per size class.

In terms of data quality and availability, SGMED 10-02 noted that data from GSA 15 was submitted late. Whilst data from commercial catches declared in GSA 16 are representative for the entire area, the lack of scientific survey data from GSA 15 did impact the overall quality of the assessment since the Central Mediterranean pink shrimp population is distributed throughout both GSAs 15 and 16. SGMED 10-02 further noted the absence of GSA 16 2009 landings data, which meant assessments based on commercial catches could only be carried out for years 2006, 2007 and 2008. Finally, an error in the GSA 16 effort data in terms of kW * Days was noted for otter board trawlers measuring > 24m in length.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Italian trawling, based in the harbors along the southern coasts of Sicily, operates both in GSA 16 and 15 with exclusion of the Maltese Fishing Management Zone (FMZ). Italian trawlers exert the most of fishing effort and yield more than 90% of deep water pink shrimp catches in the entire area. Sicilian trawlers between 12 and 24m vessel length are based in seven harbours along the southern coasts of Sicily, and operate mainly on a short-distance trawl fishery with trips from 1 to 2 days at sea. In contrast, larger trawlers measuring over 24m in length based at Mazara del Vallo carry out long fishing trips (3 – 4 weeks) in offshore waters, both national and international, of the Strait of Sicily. In 2004, larger trawlers also started fishing in the international water of the Aegean and Levant Seas. Subsequent to the recent increase of the fuel costs a critical phase for the deep water pink shrimp fishery started, affecting in particular the distant fleet, which needs about 1 ton of fuel per day during the fishing trip. The trends in fishing effort of the bottom otter trawl fleet increased from 2004 to 2007 by 32%, but declined again by 25% from 2007 to 2008. Deep water pink shrimp are the main target species of Sicilian trawlers and the species is caught both on the shelf and the upper shelf slope throughout the year. A peak in annual landing peaks can be observed from March to July. In the past total yields peaked at about 8500 t per year in 2005 / 2006, and then decreased to about 6000 tonnes in 2007 / 2008. The discarded fraction of pink shrimps by Sicilian trawlers in the last years ranged between 18 (2008) and 25 tons (2006). *P. longirostris* is fished exclusively by otter trawling, together with other species (*Nephrops norvegicus*, *Merluccius merluccius*, *Eledone* sp., *Illex coindetii*, *Todaropsis eblanae*, *Lophius* sp., *Mullus* sp., *Pagellus* sp., *Zeus faber* and *Raja* sp.).

Annual landings (t) of deep water pink shrimp by small (12m<LOA<24m) and large (LOA>24m) trawlers from official DCF data. No data submitted for 2009.

	LOA 12_24	LOA >24	total
2002	4052	3373	7425
2003	2964	4502	7466
2004	2976	3689	6665
2005	4430	4154	8584
2006	4536	3920	8456
2007	3869	2097	5966
2008	3734	2207	5941

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)=	0.62-0.72
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	

B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of pink shrimp GSAs 15 and 16 can be found in section 5.37 of this report.

4.21. Anchovy in GSA 01

Species common name:	Anchovy
Species scientific name:	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 01

Most recent state of the stock

- State of the adult abundance and biomass:

Results of the Extended Survivor Analysis (XSA) analysis indicated a slight increase from the lowest levels observed in 2008. However the anchovy SSB remains at low levels also in 2009. The state of the spawning biomass in relation to precautionary limits cannot be evaluated since there are no precautionary reference points derived due to the short series of data available. It should be considered that this assessment is based on a short time series of data and not suitable to suggest reference points of B_{pa} and B_{lim}. Moreover, anchovy is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends also on environmental conditions. No reference points were proposed for biomass levels, and hence SGMED-10-02 cannot comment on the state of the stock with this respect.

- State of the juvenile (recruits):

XSA model estimates had shown an increase in the number of recruits in 2009, well above the recruitments observed in the last four years (2005-2008) and similar to the recruitments occurred in 2003 and 2004. The trend of the recruitments is important as stocks of small pelagics and fisheries are highly dependent of the recruitment strength. SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the short time series available.

- State of exploitation:

SGMED 09-02 recommends the exploitation rate $E \leq 0.4$ as target management reference point.
The high and increasing yearly exploitation rates, as estimated by the ratio between total landings and biomass, indicates high fishing mortality levels. If this estimate of exploitation rate can be considered as equivalent to F/Z estimate obtained from the fitting of standard stock assessment models, the current exploitation (0.64) is higher than the suggested reference point. The fishing mortality level corresponding to $F/Z=0.64$ is $F=1.17$, if $M=0.66$ is estimated with Pauly (1980) empirical equation. Thus, the stock is considered to be overexploited.

- Source of data and methods:

The assessment of this stock was carried out by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999) using catch data collected by the Spanish National Data Collection. The XSA tuning was performed using abundance index series derived from echo-surveys carried out in the GSA 01 but no tuning data was available for GSA01 in 2009. Biological parameters were estimated following the recommendations of the SGMED.

Outlook and management advice

SGMED-10-02 recommends the exploitation rate to be reduced to below or at the proposed level, in order to avoid future loss in stock productivity and landings. Catches consistent with the reductions in exploitation rate should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with sardine fisheries.

Short and medium term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

The current fleet in GSA 01 the Northern Alborán Sea is composed by 131 units, characterised by small vessels. 21% of them are smaller than 12 m and 79% between 12 and 24 m. The purse seine fleet has been continuously decreasing in the last two decades, from more than 230 vessels in 1980 to 131 in 2009. Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the main target species of the purse seine fleet in Northern Alboran GSA 01, but other species with lower economical mackerel (*Trachurus spp.*), mackerel (*Scomber spp.*) and gilt sardine (*Sardinella aurita*). The annual landings of anchovy in the Northern Alborán Sea show annual fluctuations and ranged between 3268 and 178 tons. Landings increase in 2009, reaching up 292 t. Anchovy discards in GSA 01 are negligible and no effort data were reported to SGMED-10-02 through the DCF data call for Spain. The data were reported to SGMED-10-02 through the Data Collection Regulation and are listed in the next table.

Annual landings (t) by fishing technique (Spanish purse seiners) in GSA 01.

SPECIES	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008	2009
ANE	1	ESP	PS	3268	245	746	518	637	245	178	292

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 0-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of anchovy in GSA 01 can be found in section 5.41 of this report.

4.22. Anchovy in GSA 06

Species common name:	Anchovy
Species scientific name:	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 06 – Northern Spain

Most recent state of the stock

- State of the adult abundance and biomass:

Both total biomass (38,830 t) and spawning stock biomass in 2009 (26,480 t) increased from the lowest value observed in 2006. No precautionary management reference points were proposed for biomass levels, and hence SGMED cannot comment on the state of the stock with this respect.

- State of the juvenile (recruits):

Recruitment in 2009 (1380 millions) decreases compared to 2008 (2030 millions) and generally seems to follow the trend in SSB. SGMED highlighted that the stock and the fishery is highly dependent on the recruitment strength.

- State of exploitation:

Fishing mortality has generally decreased during the time series. However, F in 2009 was slightly larger than 2008. F_{0-2} in 2009 was 0.89. The exploitation rate during the last five years (E=0.6, with the exception of 2008) is above the exploitation reference points (E=0.4) proposed by Patterson (1992) and suggested by SGMED as an appropriate management reference point consistent with high long term yield for small pelagics.Based on this assessment results the stock is considered overexploited. However, SGMED stresses that the use of the exploitation rate is very sensitive to M values. It is important to stress that the fishery for small pelagics in GSA 06 is a multispecies fisheries and effort on anchovy and sardine should be considered together.

- Source of data and methods:

This assessment is based on VPA (XSA) methods. Fishery assessment by VPA methods of the Spanish anchovy stock GSA06 is shown. VPA Lowestoft software suite was used and XSA was the assessment method. A separable VPA was also run as exploratory analysis for both stocks.
Data used for XSA:

- Landings from 2002-2009 from GSA 06, available to experts in SGMED-10-02.
- Combined ALK (2003-2009) for all the years. Length Distributions 2003-2009, Length distribution 2003 was applied to 2002 landings.
- Biological sampling 2003-2009 for Maturity at age and Weight-Length relationships.
- Tuning data from acoustic survey ECOMED and MEDIAS.

Data availability was ensured to SGMED-10-02 throughout a specific DCR data call. DCR data were valuable in its whole, but some inconsistencies were found in data. In order to avoid major inconsistencies we recommend to national correspondents of member states to check data before being available to SGMED to carry out stock assessments.

Outlook and management advice

SGMED-10-02 recommends the exploitation rate to be reduced to below or at the proposed level, in order to avoid future loss in stock productivity and landings. Catches consistent with the reductions in exploitation rate should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with sardine fisheries.

Short and medium term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

The most updated fleet information corresponds to GFCM WG2009, containing data up to 2008. The purse seine fleet operating in GSA 06 Northern Spain is composed by 130 units: 4% are smaller than12 m in length, 87% between 12 and 24 m and 9% bigger than 24 m. The fleet continuously decreased in the last decade, from more than 222 vessels in 1995 to 130 in 2008. This strong reduction (59%) is possibly linked to a continous decreasing in small pelagic catches. Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are the main target species of the purse seine fleet in Northern Spain GSA 06, but other species with lower economical importance are also captured, sometimes representing a high percentage of the capture: horse mackerel (*Trachurus* spp.), mackerel (*Scomber* spp.) and gilt sardine (*Sardinella aurita*). The annual landings of anchovy (*Engraulis encrasicolus*) in the Northern Spain for the last seven years ranged between 14,338 and 2,570 t. This species is the most valuable one in pelagic fisheries off GSA 06. Discards are negliglible and no effort data were reported to SGMED-10-02 through the DCF data call for Spain.

Landings in 2009 were 9,814 t, showing a huge increase from 2008 (2,558 t). Apart from this recent 2009 increase, the time series shows a very sharp decrease from the beginning of the times series in 2002. The lowest values of the assessed time series were reported in 2008.

Annual landings (t) by fishing technique (purse seiners) in GSA 06.

Year	2002	2003	2004	2005	2006	2007	2008	2009
Catch (t)	14338	8538	8097	6216	3096	2570	2558	9814

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 0-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of anchovy in GSA 06 can be found in section 5.42 of this report.

4.23. Anchovy in GSA 09

Species common name:	Anchovy
Species scientific name:	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of propsed or agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of biomass. The analyses carried out on the data referred to the period 2006-2008 do not allow to obtain information on the spawning stock biomass. However, both landings and survey indices indicate the stock being at a low level recently (2004-2008).

- State of the juvenile (recruits):

The analyses carried out on the data referred to the period 2006-2008 do not allow to obtain information on the state of recruitment.

- State of exploitation:

SGMED-10-02 proposes E=0.4 as limit management reference point consistent with high long term yields. The current exploitation rate is higher than the reference point suggested by Patterson (0.4). Applying the exploitation rate as a reference point, this stock must be considered as overexploited and F needs a consistent reduction from the current value towards the candidate reference points to achieve long term sustainability.

- Source of data and methods:

Assessment was performed using an LCA (VIT software, Lleonart and Salat 1997) on an annual pseudo-cohort. Data coming from DCR provided at SGMED 10-02 contained, for GSA 09, information on anchovy landings and the respective size/age structure for the years 2006-2008. The short data time series did not allow applying a VPA. LCA was performed using VIT software on data of the years 2006, 2007 and 2008. The vector of natural mortality M was estimated using the software Prodbiom. No 2009 landings data were available.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009, SGMED-10-02 recommends the exploitation rate to be reduced to below or at the proposed level, in order to avoid future loss in stock productivity and landings. Catches consistent with the reductions in exploitation rate should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with sardine fisheries.

The results obtained from the assessments performed for the period 2006-2008, associated to the heavy reduction of the landing observed in the last twenty years suggest the adoption of plan for the recovery of this important resource as a matter of urgency. All the management options need to taken into account the effect on sardine, the other important resource exploited by this fishery. However, this is the first attempt to assess anchovy in the GSA 9 and, taking in to account the short data series available for the evaluation, further analyses should be carried out. The purse seine fleet operating in the GSA 9 contemporary exploit anchovy and sardine. This aspect should taken in to account for the management options that will be implemented in the future.

Short and medium term scenarios:
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

In the GSA 09, anchovy is mainly exploited by purse seiners attracting fish with light. Due to the high economic value, anchovy represents the target species for this fleet in the area; sardine (*Sardina pilchardus*) is the other important species exploited by this fishery. The fishing season starts in spring (March) and ends in autumn (October). Favorable weather conditions and abundance in the catches can extend the fishing activity to the end of November. However, the maximum activity of the fleet is normally observed in summer. Some vessels coming from the south of Italy (mainly from GSA 10) join the local fleet for the exploitation of this resource. Studies carried out in the framework of the DCF in 2005 demonstrated that discards of anchovy for the Italian fleet can be considered as negligible. Anchovy is also a by-catch in the bottom trawl fishery; however, the landing done by this *metier* is negligible in comparison to that of purse seine (less than 5%). Pelagic trawling is not present in the GSA 09.

Landings (t) by year and major gear types, 2002-2008 as reported through DCR.

2002	2003	2004	2005	2006	2007	2008
6975	4582	1494	2108	3727	2292	1355

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 0-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of anchovy in GSA 09 can be found in section 5.43 of this report.

4.24. Anchovy in GSA 16

Species common name:	Anchovy
Species scientific name:	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 16 – South of Sicily

Most recent state of the stock

Due to data constraints SGMED10-02 did not update the stock assessment conducted in 2009 by SGMED-09-02. This section reiterates the findings in 2009 in order to facilitate regional overviews of stocks and fisheries' status and contributes to improved consistency regarding the scientific advice.

- State of the adult abundance and biomass:

Biomass estimates of total population obtained by hydro-acoustic surveys for anchovy in GSA 16 show a decreasing trend over the last years. The 2008 estimate is the lowest value of the series and represents approximately just one-tenth of the maximum recorded value. However, in the absence of proposed or agreed precautionary management reference points, SGMED-10-02 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them.

- State of the juvenile (recruits):

No recruitment data were provided by this assessment.

- State of exploitation:

SGMED 10-02 recommends the exploitation rate $E \leq 0.4$ as target management reference point.
The high and increasing yearly exploitation rates, as estimated by the ratio between total landings and biomass, indicates high fishing mortality levels. If this estimate of exploitation rate can be considered as equivalent to F/Z estimate obtained from the fitting of standard stock assessment models, the current exploitation (0.64) is higher than the suggested reference point. The fishing mortality level corresponding to $F/Z=0.64$ is $F=1.17$, if $M=0.66$ is estimated with Pauly (1980) empirical equation. Thus, the stock is considered to be overexploited.

- Source of data and methods:

Census data for catch and effort data were obtained from census information (on deck interviews) in Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA16), accounting for about 2/3 of total landings in GSA 16. Acoustic data were used for fish biomass evaluations. Natural mortality was set at 0.66, estimate obtained with Pauly (1980) empirical equations. An attempt to fit a surplus production (logistic) model to the available data series (catch-effort and acoustic biomass estimates) was also done by means of ASPIC (Prager, 1994), but results were not mentioned in this document as the basic assumption about the proportionality between CPUE and biomass was not fulfilled.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009, SGMED-10-02 recommends that exploitation should be reduced towards F/Z= 0.4 in order to promote stock recovery and avoid future loss in stock productivity and landings. Catches consistent with the reductions in exploitation rate should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with sardine fisheries.

Taking into account that fishing effort was relatively stable in last decade, whereas CPUE trend was even increasing, results would suggest that also environmental factors are important to explain the variability on yearly recruitment success. However, the stock biomass did not recover from the 2006 "collapse" in biomass (-69% from July 2005 to June 2006), and even further decreased (-53%) in 2008. This fact, along with the quite high and increasing level of exploitation rates experienced over the last years, also suggests questioning about the sustainability of current fishing. In addition, possible negative effects on the stock could result from pressure of other fishing gears on larval stages.

A warning on the fishing of larval stages (locally named *bianchetto*) is also relevant for anchovy population if derogation of the fishing ban, normally operated for GSA 16 in wintertime, is postponed after the start of the anchovy spawning season, even though more data and investigation are needed in order to estimate the possible impact of this fishing activity on the exploited populations.

Short and medium term scenarios:
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

In Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA16), accounting for about 2/3 of total landings in GSA 16, two operational units (OU) are presently active, purse seiners and pelagic pair trawlers. The fleet in GSA16 is composed by about 50 units (17 purse seiners and 30 pelagic pair trawlers were counted up in a census carried out in December 2006). In both OUs, anchovy represents the main target species due to the higher market price.

Average anchovy landings over the last decade (1997-2008) were about 1,600 metric tons, with large inter-annual fluctuations. Total effort was slightly increasing over the same period.

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 0-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of anchovy in GSA 16 can be found in section 5.44 of this report.

4.25. Anchovy in GSA 20

Species common name:	Anchovy
Species scientific name:	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 20

Most recent state of the stock

- State of the adult abundance and biomass:

Estimates of XSA stock assessment model for anchovy in GSA 20 indicated a decrease in SSB was observed since 2002 but with a slight increase since 2006 to 2008 reaching 1200 t in 2008. In the absence of proposed or agreed precautionary reference points, SGMED-10-02 is unable to fully evaluate the state of the stock in respect to biomass reference points. It should be considered that this assessment is based on a short time series of data and not suitable to suggest reference points of B_{lim}. Moreover, anchovy is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends on environmental conditions.

- State of the juvenile (recruits):

XSA model results for anchovy stock in GSA 20 indicated the highest values of recruitment in 2001 and 2006, decreasing however towards 2008.

- State of exploitation:

SGMED-10-02 proposes E=0.4 as limit management reference point consistent with high long term yield. Based on XSA results, the mean fishing mortality (averaged over ages 1 to 3) is highly variable fluctuating around 0.4. However, since XSA was tuned with unstandardised CPUE of the purse seine fleet, exploitation rates might be underestimated. The purse seine fleet showed a sharp increase concerning its capacity since 2005 that might bias the model estimates, resulting into underestimation of the exploitation rate.

The mean F/Z concerning the anchovy stock in GSA 20 was on average above (mean value of the entire time series equals 0.41) the empirical level of sustainability (E<0.4, Patterson 1992) for small pelagics. Taking into account that this value could be an underestimation of the actual situation, the SGMED recommends a reduction in fishing mortality in order to reach the F/Z= 0.4, promote stock recovery and avoid future loss in stock productivity and landings.

- Source of data and methods:

The time series terminates in 2008 with a gap of data in 2007. No data were available for 2009. No information from fisheries independent surveys such as acoustics or DEPM was available. Data from 2007 were missing so input data were based on unreported data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers GSA 20. This assessment is based on fishery independent surveys information as well as on Extended Survivor Analysis (XSA) model. XSA assessment method uses virtual population analysis (VPA) with weighted tuning indices. The application of XSA was based on commercial catch data (2000-2008) and as tuning index the Catch per Unit Effort estimates were used. Anchovy data were comprised of annual anchovy landings, annual anchovy catch at age data (2000-2008), mean weights at age, maturity at age at age. Different natural mortality were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. This method of the estimation of the natural mortality is consistent with the methodology used in GSAs 5, 6 and 17 for small pelagics. Discards were also included within this assessment representing however only 0.3 % of total landings.Y/R analyses were performed but were not considered reliable due to its flat-topped shape.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009, SGMED-10-02 recommends that exploitation should be reduced towards F/Z= 0.4 in order to promote stock recovery and avoid future loss in stock productivity and landings. Catches consistent with the reductions in exploitation rate should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with sardine fisheries.

Short, medium and long term scenarios:
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

In GSA 20 (Greek part) anchovy is almost exclusively exploited by the purse seine fleet. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Regarding the regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore, gear and mesh size, engine, GT. There is a minimum landing size at 9 cm. Anchovy landings have been highly variable, showing maximum values in 2003 decreasing up to 2007 and then increasing to 1326 tons in 2008. Information regarding the age and length distribution of anchovy landings prior to 2003 is based on the Hellenic Centre of Marine Research data collection system. Data of the fishing effort (Days at Sea) and the landings per vessel class indicate that small vessels (12-24 m) are entirely responsible for anchovy catches. Discards values are less than 1%, reaching approximately 0.06% data for GSA 20.

Annual landings (in t) in GSA 20 per vessel size for 2003 to 2008 concerning the purse seine fleet in Greek waters.

Year	PS 12-24 m
2003	1949
2004	116
2005	990
2006	672
2007	341
2008	1326

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 1-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment
The detailed assessment of anchovy in GSA 20 can be found in section 5.45 of this report.

4.26. Anchovy in GSA 22

Species common name:	Anchovy
Species scientific name:	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 22

Most recent state of the stock

Due to data constraints SGMED10-02 did not update the stock assessment conducted in 2009 by SGMED-09-02. This section reiterates the findings in 2009 in order to facilitate regional overviews of stocks and fisheries' status and contributes to improved consistency regarding the scientific advice.

- State of the adult abundance and biomass:

Given the short length of the time series, SGMED is unable to precisely estimate the absolute levels of stock abundance and biomass. Survey indices and VPA analyses indicate that average total biomass and SSB increased since 2005 to 2008. Precautionary biomass reference points have not been estimated for this stock, and hence advice relative to these cannot be provided by SGMED in respect to those.

- State of the juvenile (recruits):

ICA model estimates suggest an increase in recruitment since 2004, with a pronounced increase in 2008. However the model predicts a decrease in the population abundance at age 0 for 2009 to the 2006 abundance level.

- State of exploitation:

SGMED recommends the application of the proposed exploitation rate $E \leq 0.4$ as management target for stocks of anchovy and sardine in the Mediterranean Sea. This value might be revised in the future when more information becomes available. Based on ICA results, the mean $E=F/Z$ (F averaged over ages 1 to 3) has fluctuated around 0.36 and since 2004 has been below the empirical level of sustainability suggested as target exploitation level for this stock. Thus, the stock is considered to be exploited sustainably until 2008.

- Source of data and methods:

This assessment is based on fishery independent surveys information as well as on Integrated Catch at Age (ICA) analysis model. The application of ICA was based on commercial catch data (2000-2008) and as tuning indices were used the biomass estimates from acoustic surveys and the Daily Egg Production Method (DEPM) estimates over the period 2003-2008 but with a gap for 2007. Different natural mortality were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. This method of the estimation of the natural mortality is consistent with the methodology used in GSAs 5, 6 and 17 for small pelagics. Reference age for the fishery was age group 2, as fully exploited and fully recruited. The age groups 0, 4 and 5 were underweighted in the analysis based on their percentage in the catch. Age 1 was also underweighted in the acoustic surveys (0.5). Catchability for the DEPM index is assumed as absolute indicator of biomass and linear catchability relationship is assumed for the acoustic surveys. Information regarding the age and length distribution of sardine landings prior to 2003 is based on the Hellenic Centre of Marine Research data collection system.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Taking the empirical level $E \leq 0.4$ as a limit management reference point consistent with high long term yields and assuming status quo fishing in 2009, the stock is considered to be exploited sustainably. Increased fishing is not expected to result in increased landings in the long term. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with sardine fisheries.

For precautionary reasons the possibility of changing the closed period should be examined. Since the purse seine fishery is a multispecies fishery targeting both anchovy and sardine, a shift of the closed period (present: mid December to end of February) towards the recruitment period of anchovy (e.g. October to December) / or the recruitment period of sardine (e.g. February to April) could be suggested. This approach has the potential to improve the selectivity of the fishery, and thus provide higher potential catch in the long term.

<u>Short, medium and long term scenarios:</u>
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

In GSA 22 (Greek part) anchovy is almost exclusively exploited by the purse seine fleet. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Regarding the regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore, gear and mesh size, engine, GT. There is a minimum landing size at 9 cm. Discards values are less than 1%, reaching approximately 0.06% data for GSA 22.

Annual landings (t) in GSA 22 per vessel size for 2003 to 2008 concerning the purse seine fleet in Greek waters. Since there was no Data Collection Program in Greece in 2007, data concerning this year are estimations of the Hellenic Centre for Marine Research based on data from other research projects that were held in GSA 22.

Year	PS 12-24 m	PS 24-40 m
2003	12507	1495
2004	12222	3877
2005	11073	5274
2006	16121	6190
2007	14875	6625
2008	18188	6293

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 1-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment
The detailed assessment of anchovy in GSA 22 can be found in section 5.46 of this report.

4.27. Sardine in GSA 01

Species common name:	Sardine
Species scientific name:	*Sardina pilchardus*
Geographical Sub-area(s) GSA(s):	GSA 01

Most recent state of the stock

- State of the adult abundance and biomass:

Results of the Extended Survivor Analysis (XSA) analysis indicated a slight decrease from the highest levels observed in 2005. However the sardine SSB remains at medium-high levels also in 2009. The state of the spawning biomass in relation to precautionary limits cannot be evaluated since there are no precautionary reference points proposed or agreed due to the short series of data available. It should be considered that this assessment is based on a short time series of data and not suitable to suggest reference points of B_{lim}. Moreover, sardine is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends on environmental conditions.

- State of the juvenile (recruits):

XSA model estimates had shown an increase in the number of recruits in the last two years (2008-2009). In 2009 recruitment was well above the minimum recruitment level observed in 2007. The trend of the recruitments is important as stocks of small pelagics and fisheries are highly dependent of the recruitment strength.

- State of exploitation:

Based on XSA results, the mean F (for ages 1 to 3) followed a decreasing trend along the time series (2000-2009) and remains at low levels in 2009. The exploitation rate during the last eight years is below the exploitation reference points (E=0.4) proposed by Patterson (1992) and suggested by SGMED as an appropriate limit management reference point consistent with high long term yields for small pelagics. Based on this assessment results the stock is considered sustainably exploited. However, SGMED stresses that the use of the exploitation rate is very sensitive to M values.

- Source of data and methods:

The assessment of this stock was carried out by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999) using catch data collected by the Spanish National Data Collection. The XSA tuning was performed using abundance index series derived from echo-surveys carried out in the GSA 01 but no tuning data was available for GSA 01 in 2009. Biological parameters were estimated following the recommendations of the SGMED.

Outlook and management advice

SGMED-10-02 recommends the exploitation rate being kept below or at the proposed reference level, in order to avoid future loss in stock productivity and landings. Catches consistent with that exploitation level consistent with high long term yields should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with anchovy fisheries.

Short and medium term scenarios:

To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

The current fleet in GSA 01 the Northern Alborán Sea is composed by 131 units, characterised by small vessels. 21% of them are smaller than 12 m and 79% between 12 and 24 m. The purse seine fleet has been continuously decreasing in the last two decades, from more than 230 vessels in 1980 to 131 in 2009.
Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the main target species of the purse seine fleet in Northern Alboran GSA 01, but other species with lower economical mackerel (*Trachurus spp.*), mackerel (*Scomber spp*.) and gilt sardine (*Sardinella aurita*) are also caught.

The annual landings of sardine in the Northern Alborán Sea show annual fluctuations ranged between 3960 and 10000 tons. The data were reported to SGMED-10-02 through the Data Collection Regulation and are listed in the next table. Sardine discards in GSA 01 are negligible and no effort data were reported to SGMED-10-02 through the DCF data call for Spain.

Annual landings (t) by fishing technique (Spanish purse seiners) in GSA 01.

SPECIES	AREA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
PIL	1	9325	7457	5348	8244	3964	7208	10002	6766	4423	5926

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 1-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of sardine in GSA 01 can be found in section 5.47 of this report.

4.28. Sardine in GSA 06

Species common name:	Sardine
Species scientific name:	*Sardina pilchardus*
Geographical Sub-area(s) GSA(s):	GSA 06

Most recent state of the stock

- State of the adult abundance and biomass:

SSB is has largely declined, reaching its minimum values in the recent years. Spawning Stock Biomass in 2009 (SSB=25,720 t) is practically the same of 2008 (SSB=25,450 t), the lowest observed SSB values in the time series. No precautionaray reference points were proposed for biomass levels, and hence SGMED cannot comment on the state of the stock with this respect.

- State of the juvenile (recruits):

Recruitment in 2009 (R09=2250 millions) increases compared to 2008 (1160 millions), the minimum of the time series considered. The trend of the recruitments is so important as they can affect seriously to the stock health. SGMED emphasises that the stock and the fishery is highly dependent on the recruitment strength.

- State of exploitation:

SGMED-10-02 proposes E=0.4 as limit management reference point consistent with high long term yields. Fishing mortality has decreased since the beginning of the time series till 2005 (F_{0-2} in 2005 =0.70), with the exception of a peak in 2001. Since 2005, F increased, reaching its maximum in 2008 (F_{0-2} in 2008 =2.55). The exploitation rate during the last five years (E=0.8) is estimated to exceed the exploitation reference points (E=0.4) proposed by Patterson (1992) and suggested by SGMED as an appropriate reference point for small pelagics. Based on this assessment results the stock is considered overexploited. However, SGMED stresses that the use of the exploitation rate is very sensitive to M values. It is important to stress that small pelagic fishery in GSA 06 is a multispecies fisheries and effort on anchovy and sardine should be considered together.

- Source of data and methods:

The assessment of this stock was carried out by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999) using catch data collected by the Spanish National Data Collection. Biological parameters were estimated following the recommendations of the SGMED. No effort data were reported by Spain to SGMED-10-02 through the DCF data call. Thus, SGMED was unable to conduct an analysis of the effort trend for the major fleets fishing sardine in GSA 06.

Outlook and management advice

SGMED-10-02 recommends the exploitation rate being reduced to below or at the proposed reference level, in order to avoid future loss in stock productivity and landings. Catches consistent with that exploitation level consistent with high long term yields should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with anchovy fisheries.

Short and medium term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

The most updated fleet information corresponds to GFCM WG2009, containing data up to 2008. The purse seine fleet operate in GSA 06 Northern Spain is composed by 130 units: 4% are smaller than12 m in length, 87% between 12 and 24 m and 9% bigger than 24 m. The fleet continuously decreased in the last decade, from more than 222 vessels in 1995 to 130 in 2008. This strong reduction (59%) is possibly linked to a continous decreasing in small pelagic catches. Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the main target species of the purse seine fleet in Northern Spain GSA 06, but other species with lower economical importance are also captured, sometimes representing a high percentage of the capture: horse mackerel (*Trachurus* spp.), mackerel (*Scomber* spp.), and gilt sardine (*Sardinella aurita*).

The annual landings of sardine (*Sardina pilchardus*) in the Northern Spain for the whole time series ranged between 52,440 and 7,900 t. Landings in 2009 were 7,900 t. This is the lowest values of the assessed time series, halving the catch from 2008 (14,120 t) which is the second lowest value of the time series. The highest value of the time series corresponds to the first year analysed (1994 with 52,440 t). Hence, the time series shows a continuous and very sharp decrease from the beginning of the times series. Discards are negligible and no effort data were reported to SGMED-10-02 through the DCF data call for Spain.

Annual sardine landings (t) by fishing technique (purse seiners) in GSA 06.

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002
Catch (t)	52439	48525	44387	35618	32274	36142	36972	30275	18762

Year	2003	2004	2005	2006	2007	2008	2009
Catch (t)	20817	24874	22081	29381	23984	14123	7896

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 0-2)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of sardine in GSA 06 can be found in section 5.48 of this report.

4.29. Sardine in GSA 16

Species common name:	Sardine
Species scientific name:	*Sardina pilchardus*
Geographical Sub-area(s) GSA(s):	GSA 16 – South of Sicily

Most recent state of the stock

Due to data constraints SGMED-10-02 did not update the stock assessment conducted in 2009 by SGMED-09-02. This section reiterates the findings in 2009 in order to facilitate regional overviews of stocks and fisheries' status and contributes to improved consistency regarding the scientific advice.

- State of the adult abundance and biomass:

Biomass estimates of the total population obtained by hydro-acoustic surveys for sardine in GSA 16 show that the recent stock level is well below the average value over the last decade. However, in the absence of proposed or agreed references, SGMED-10-02 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them.

- State of the juvenile (recruits):

Data not available.

- State of exploitation:

SGMED recommends the application of the proposed exploitation rate $E \leq 0.4$ as management target for stocks of anchovy and sardine in the Mediterranean Sea. This value might be revised in the future when more information becomes available.Annual exploitation rates, as estimated by the ratio between total landings and biomass, indicates relatively low fishing mortality during the last decade. If this estimate of exploitation rate can be considered as equivalent to F/Z estimate obtained from the fitting of standard stock assessment models, the current exploitation rate (0.22) and even all the previous available estimates are lower than the reference point suggested by Patterson (1992). The fishing mortality level corresponding to F/Z=0.22 is F=0.14, if M=0.51, estimated with Pauly (1980) empirical equation, is assumed. Using the exploitation rate as a target reference point, the stock of sardine in GSA 16 is considered as being sustainably exploited.

- Source of data and methods:

Census data for catch and effort data were obtained from census information (on deck interviews) in Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA16), accounting for about 2/3 of total landings in GSA 16. Acoustic data were used for fish biomass evaluations. Natural mortality was set at 0.51, estimate obtained with Pauly (1980) empirical equations. An attempt to fit a surplus production (logistic) model to the available data series (Catch-effort and acoustic biomass estimates) was also done by means of ASPIC software ver. 5.33 (Prager, 1994), but results were not mentioned in this document, mainly due to their quite high variability depending on the adopted parameter starting guesses in the estimation procedure. Catch data for 2009 were not submitted by the Italian authorities.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009, SGMED-10-02 recommends the relevant fleet effort should not be allowed to increase in order to avoid future loss in stock productivity and landings. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with anchovy fisheries. In addition, due to the low level of the anchovy stock, measures should be taken to prevent a shift of effort from anchovy to sardine.

Taking into account that fishing effort was relatively stable in the last decade, results would suggest that also environmental factors are important to explain the variability on yearly recruitment success. However, the stock did not recover from the 2006 "collapse" in biomass (-52% from July 2005 to June 2006), and this fact, along with the moderate exploitation rates experienced over the last decade and the decreasing trend in landings, also suggests questioning about the sustainability of current levels of fishing effort. In addition, possible negative effects on these populations could results from pressure of other fishing gears on larval stages.

A warning on the fishing of larval stages (locally named *bianchetto*) is relevant, taking into account that in the past years derogation of the fishing ban was normally operated in wintertime, i.e. during the sardine spawning season, even though more data and investigation are needed in order to estimate the possible impact of this fishing activity on the exploited populations.

- Short, medium and long term scenarios

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

In Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16, two operational units (OU) are presently active, purse seiners and pelagic pair trawlers. The fleet in GSA 16 is composed by about 50 units (17 purse seiners and 30 pelagic pair trawlers were counted up in a census carried out in December 2006). In both OUs, anchovy represents the main target species due to the higher market price.

Average sardine landings over the last decade (1997-2008) were about 1,500 metric tons, with a general decreasing trend. Total effort was slightly increasing over the same period.

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of sardine in GSA 16 can be found in section 5.49 of this report.

4.30. Sardine in GSA 20

Species common name:	Sardine
Species scientific name:	*Sardina pilchardus*
Geographical Sub-area(s) GSA(s):	GSA 20

Most recent state of the stock

- State of the adult abundance and biomass:

Estimates of XSA stock assessment model for sardine in GSA 20 indicated an increase since 2004 reaching 5,600 t in 2008. In the absence of proposed or agreed references, SGMED-10-02 is unable to fully evaluate the state of the stock and provide scientific advice in respect to precautionary biomass reference points.

- State of the juvenile (recruits):

XSA model estimates had showed an increase in the number of recruits towards 2007 but a decrease was estimated by the stock assessment model in 2008.

- State of exploitation:

SGMED proposes E=0.4 as limit management reference point consistent with high long term yield. Based on XSA results, the mean fishing mortality (averaged over ages 1 to 3) is highly variable, being below 1 in all years and decreasing since 2005 but approximating 0.68 in 2008. However, since XSA was tuned with unstandardised CPUE of the purse seine fleet, exploitation rates might be underestimated. The purse seine fleet showed a sharp increase concerning its capacity since 2005 that might bias the model estimates, resulting into underestimation of the exploitation rate. The exploitation rate below the empirical level for stock decline (E<0.4, Patterson 1992) was suggested by the SGMEDas reference point for small pelagics. Therefore, the mean F/Z concerning the sardine stock in GSA 20 was on average above (mean value of the entire time series equals 0.46) the empirical level of sustainability (E<0.4, Patterson 1992) for small pelagics. Taking into account that this value could be an underestimation of the actual situation, the SGMED recommends a reduction in fishing mortality in order to reach the F/Z= 0.4, promote stock recovery and avoid future loss in stock productivity and landings. Therefore, taking the empirical level as a reference point for sustainable exploitation, the stock is considered to be overexploited. Fishing mortality should be reduced in order to allow future recruitment contributing to stock productivity. This requires also consideration of the mixed fisheries nature of the fleets.

- Source of data and methods:

The time series of stock relevant data terminates in 2008 with a gap of data in 2007. No data were available for 2009. No information from fisheries independent surveys such as acoustics or DEPM was available. Data from 2007 were missing so input data were based on unreported data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers GSA 20. This assessment is based on fishery independent surveys information as well as on Extended Survivor Analysis (XSA) model. XSA assessment method uses virtual population analysis (VPA) with weighted tuning indices. The application of XSA was based on commercial catch data (2000-2008) and as tuning index the Catch per Unit Effort estimates were used. Sardine data were comprised of annual sardine landings, annual sardine catch at age data (2000-2008), mean weights at age, maturity at age at age. Different natural mortality were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01 applying the same growth parameters used in GSA 22. This method of the estimation of the natural mortality is consistent with the methodology used in GSA 22 for small pelagics. Discards were also included within this assessment representing however only 0.3 % of total landings. Y/R analyses were performed but were not considered reliable due to its flat-topped shape.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009, SGMED-10-02 recommends that exploitation should be reduced towards F/Z= 0.4 in order to promote stock recovery and avoid future loss in stock productivity and landings. Catches consistent with the reductions in exploitation rate should be estimated. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with anchovy fisheries.

Short, medium and long term scenarios:
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries
In GSA 20 sardine is almost exclusively exploited by the purse seine fleet. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Regarding the regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore, gear and mesh size, engine, GT. There is a minimum landing size at 11 cm. Sardine landings showed high variability with highest values in 2005 (1900 ton) and in 2008 (2900 ton). Information regarding the age and length distribution of sardine landings prior to 2003 is based on the Hellenic Centre of Marine Research data collection system. Data of the fishing effort (Days at Sea) and the landings per vessel class indicate that small vessels (12-24 m) are entirely responsible for sardine catches. The purse seine fishery is considered a mixed fishery, where sardine, anchovy and other species are caught. Discards were also included within this assessment representing however only 0.3 % of total landings.

Annual landings (t) in GSA 20 per vessel size for 2003 to 2006 and 2008 concerning the purse seine fleet in Greek waters derived from data provided to DCR call.

Year	PS 12-24 m
2003	1861
2004	734
2005	1925
2006	1377
2008	2807

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 1-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of sardine in GSA 20 can be found in section 5.50 of this report.

4.31. Sardine in GSA 22

Species common name:	Sardine
Species scientific name:	*Sardina pilchardus*
Geographical Sub-area(s) GSA(s):	GSA 22

Most recent state of the stock

Due to data constraints SGMED-10-02 did not update the stock assessment conducted in 2009 by SGMED-09-02. This section reiterates the findings in 2009 in order to facilitate regional overviews of stocks and fisheries' status and contributes to improved consistency regarding the scientific advice.

- State of the adult abundance and biomass:

The results of the short time series of data do not allow concluding on reference points of B_{lim} or B_{pa}. In the absence of proposed or agreed references, SGMED-10-02 is unable to fully evaluate the state of the stock and provide scientific advice. Results of the Integrated Catch at Age analysis indicated an increasing trend in total biomass and SSB showing a slight recovery of SSB to 20,000 t in 2008 from the low 2003-2004 estimates of 7,000 t.

- State of the juvenile (recruits):

ICA model estimates showed above average recruitment since 2007, with a very high peak in 2008.

- State of exploitation:

SGMED-10-04 proposes E=0.4 as limit management reference point consistent with high long term yields. Based on ICA results, the mean fishing mortality (averaged over ages 1 to 3) is highly variable but showed a clear decreasing trend since 2006, amounting approximating 0.64 in 2008. The mean F/Z has declined from 2003 reaching the value of 0.41 which approximates the exploitation reference points (E<0.4, Patterson 1992) suggested by SGMED for small pelagics. Taking into account the uncertainty in the estimate, SGMED-10-02 considers the stock as being harvested sustainably.

- Source of data and methods:

This assessment is based on fishery independent surveys information as well as on Integrated Catch at Age (ICA) analysis model. Acoustic surveys estimations were used for Total Biomass estimates. ICA assessment method uses separable virtual population analysis (VPA) with weighted tuning indices. The application of ICA was based on commercial catch data (2000-2008) and as tuning indices were used the biomass estimates from acoustic surveys estimates over the period 2003-2008 with a gap in 2007, as no acoustic survey data were available for this year. Sardine data were comprised of annual sardine landings, annual sardine catch at age data (2000-2008), mean weights at age, maturity at age at age and the results of acoustic surveys. Different natural mortality were applied per age group but constant for all years based on ProdBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. This method of the estimation of the natural mortality is consistent with the methodology used in GSAs 5, 6 and 17 for small pelagics. Reference age for the fishery was age group 2, as fully exploited and fully recruited. The age groups 0, 4 and 5 were underweighted in the analysis based on their percentage in the catch. Age 1 was also underweighted in the acoustic surveys (0.5). Linear catchability relationship assumed for the acoustic surveys. Discards were also included within this assessment representing however only 0.3 % of total landings. Y/R analyses were performed but were not considered reliable due to its flat-topped shape.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Taking the empirical level E≤ 0.4 as a limit management reference point consistent with high long term yields and assuming status quo fishing in 2009, the stock is considered to be exploited sustainably. Increased fishing is not expected to result in increased landings in the long term. SGMED notes that mere effort management of fisheries targeting stocks of small pelagics implies a high risk due to their schooling behavior and the multi-species character of their fisheries (changing target species as available and

appropriate). SGMED rather recommends the consideration of landing restrictions as a more effective management tool for small pelagics. SGMED recommends a multi-annual management plan being implemented taking into account mixed-fisheries effects, in particular the technical relation with anchovy fisheries.
For precautionary reasons the possibility of changing the closed period should be examined. Since the purse seine fishery is a multispecies fishery targeting both anchovy and sardine, a shift of the closed period (present: mid December to end of February) towards the recruitment period of anchovy (e.g. October to December) / or the recruitment period of sardine (e.g. February to April) could be suggested. This approach has the potential to improve the selectivity of the fishery, and thus provide higher potential catch in the long term.

- Short, medium and long term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

In GSA 22 (Greek part) sardine is almost exclusively exploited by the purse seine fleet. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Regarding the regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore, gear and mesh size, engine, GT. There is a minimum landing size at 11 cm. Sardine landings showed high variability indicating a decreasing trend since 2005 to 2008, comprising approximately 9700 tons in 2008. Information regarding the age and length distribution of sardine landings prior to 2003 is based on the Hellenic Centre of Marine Research data collection system. Data of the fishing effort (Days at Sea) and the landings per vessel class indicate that small vessels (12-24 m) are mainly responsible for sardine catches (> 88% of the total catches). The purse seine fishery is considered a mixed fishery, where sardine, anchovy and other species are caught. Discards were also included within this assessment representing however only 0.3 % of total landings.

Landings (in t) in GSA 22 per vessel size for 2003 to 2006 and 2008 concerning the purse seine fleet in Greek waters derived from data provided to DCR call.

Year	PS 12-24 m	PS 24-40 m
2003	7158	634
2004	7267	902
2005	12159	1468
2006	11618	1166
2007	6603	1948
2008	7704	1447

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

E_{msy} (F/Z, F age range 1-3)=	≤0.4
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	

B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of sardine in GSA 22 can be found in section 5.51 of this report.

4.32. Sole in GSA 17

Species common name:	Sole
Species scientific name:	*Solea solea*
Geographical Sub-area GSA:	GSA 17

Most recent state of the stock

- State of the adult abundance and biomass:

According to the XSA and SURBA analyses the SSB was practically constant in the period considered. In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the stock size.

- State of the juvenile (recruits):

According to the XSA and SURBA analyses the recruitment of sole in GSA 17 fluctuated since 2005, despite of the fact that the SSB remained practically constant during this period.

- State of exploitation:

SGMED-10-02 proposes $F_{0.1}$=0.26 as limit management reference point consistent with high long term yield. Based on the XSA estimates of the fishing mortality in 2009 (F_{0-4}=1.36), which by far exceeds $F_{0.1}$, SGMED-10-02 concludes that the resource is subject to overfishing. SGMED recommends reductions in fishing effort of the relevant fleets and consistent reductions in landings by means of a multi-annual management plan being agreed and implemented. Such plan needs to account for multi-species effects of such fisheries.

- Source of data and methods:

SGMED-10-02 has updated the assessment carried out during the SGMED-09-02 with 2009 catch data. Also the maturity ogive, the mean weight at age and the natural mortality has been updated on the base of new biological data available for the years 2008-2009. This assessment is based on VPA (XSA) methods. VPA Lowestoft software suite (Darby and Flatman 1994) was used and XSA was the assessment method. A separable VPA (Pope and Sheperd, 1982) was also run as exploratory analysis for this stock. In addition, a yield-per-recruit (Y/R) analysis was carried out (Yield program; Branch *et al*., 2000). Data used for XSA:

- Catch numbers at age from 2005-2009 from all fishing harbours of GSA 17.
- Biological sampling 2005-2009 for maturity at age and length-weight relationships.
- M vector, estimated using PROBIOM.
- Tuning data from *rapido* trawl surveys for years 2005 to 2009.

Data derived from a regional project (SoleMon) founded by MIPAF and ADRIAMED. Catch data and catch length composition from the Italian side were obtained from on board observations and auction documents of the principal markets of the Italian coast. Catch data from the eastern side of the GSA17 were not available during the SGMED 10-02, but 150 tons were considered a good estimation on the base of the Croatian fishery data presented in the report of the 12th session of the Scientific Advisory Committee (GFCM: XXXIV/2010/Inf.9). The length frequency distribution of the Croatian catches derived from the demography of common sole observed in the hauls performed close to the Croatian waters during the SoleMon survey. Length data were transformed to age data by slicing (LFDA 5.0) using the parameters estimated by length-frequency distributions from surveys (L_{inf}: 39.6 cm; k: 0.44 y^{-1}; t_0: -0.46 y). Discard of *S. solea* is negligible (also damaged specimens are sold at a lower price), information on the level of mis-reporting for this stock has been provided in the framework of the SoleMon project. The stock was also assessed by SURBA methods. Both XSA and SURBA methods gave the same perception of the state of the stock.

Outlook and management advice

SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Specific studies on rapido trawl selectivity are necessary. In fact, it is not sure that the adoption of a larger mesh size would correspond to a decrease of juvenile catches, considering that the mesh opening currently used by the Italian rapido trawlers is larger (48 mm or more) than the legal one. The same uncertanty regards the adoption of square mesh. SSB increased over the 5 years seems to be stable, maybe because in late fall - winter the main spawning area is only partially exploited by the Croatian set netters and Italian fleets. The safeguard of such area to prevent a possible future exploitation might be crucial for the sustainability of the Adriatic sole stock. Finally, a set of specific management rules for *rapido* trawl fishery would be advisable (e.g.: size and number of gears, mesh size, towing speed).

Short, medium and long term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

The Italian fleets exploit this resource with *rapido* trawl and set nets (gill nets and trammel nets), while only trammel net is used in the countries of the eastern coast. Sole is an accessory species for otter trawling. More than 90% of catches come from the Italian side. Landings fluctuated between 1,000 and 2,300 t in the period 1996-2006 (data source: FAO-FishStat and IREPA-SISTAN time series). The fishing effort applied by the Italian *rapido* trawlers gradually increased from 1996 to 2005, and slightly decreased in the last years.
Exploitation is based on young age classes, mainly 1 and 2 year old individuals, with immature fraction dominating the landings. In 2009, the annual landings of this species were around 2135 tons in the overall GSA. From SoleMon project data, the overall Italian fleet exploiting sole in the GSA 17 is made up by around 1,300 vessels. Otter and rapido trawlers carry out their activity all year round, with the only exception of the fishing ban (end of July – beginning of September), while set netters show a seasonal activity (spring-fall). The fishing grounds exploited by rapido trawlers extend from 5.5 km from the shoreline to 50-60 m depth, while otter trawlers carry out their activity in the overall area, except for the Croatian waters. Set netters operate in the shallower waters usually close to the fishing harbours.

Year	**2005**	**2006**	**2007**	**2008**	**2009**
GSA17Landings (t)	2067	2008	1673	2184	2135
Effort (days)	152,182	122,669	108,830	116,860	134,430

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (Y/R, sexes combined, ages 0-4)	≤0.26
F_{max} (Y/R, sexes combined)=	
Z_{max} (Y/R, sexes combined)=	
Z_{mean} (0-4, sexes combined)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of sole in GSA 17 can be found in section 5.52 of this report.

4.33. Blue and red shrimp in GSA 06

Species common name:	Red shrimp
Species scientific name:	*Aristeus antennatus*
Geographical Sub-area(s) GSA(s):	GSA 06

Most recent state of the stock

Due to data constraints SGMED-10-02 did not update the stock assessment conducted in 2009 by SGMED-09-02. This section reiterates the findings in 2009 in order to facilitate regional overviews of stocks and fisheries' status and contributes to improved consistency regarding the scientific advice.

- <u>State of the adult abundance and biomass:</u>

SGMED-10-02 cannot evaluate the state of the spawning stock relative to precautionary management reference points, as these have not been proposed or defined. Since 2002, SSB, with an average for the whole period of 637 mt, declined rapidly from 2002 to 2004 reaching the lowest value (384 t) observed in 2002-2008 which represents a 25% of that observed in 2002. Thereafter, SSB is estimated to increase until 2008 almost to the level seen in the beginning of the assessed time period. SGMED-10-02 notes that the MEDITS survey abundance index shows oscillations along the period, generally decreasing from 1996 to 2007 and largely increasing in 2008 and 2009. The large variation in the CPUE might be related to the fact that MEDITS survey is principally able to track recruitment or that the SSB is such low that the stock (and relative stock indices) is highly dependent to the incoming year classes. However, this would require further data and analysis.

- <u>State of the juvenile (recruits):</u>

Recruits (aged 0 individuals) were estimated to increase significantly from 2003 to 2007 and remain high in 2008.

- <u>State of exploitation:</u>

Mean fishing mortality from 2002 to 2008 varied without a clear trend between 0.8 and 1.3. The highest value is observed in 2008, the terminal year of the analysis. The lack of proposed and agreed limit management reference point for exploitation consistent with high long term yields causes SGMED-10-02 being unable to fully evaluate the state of exploitation.

- <u>Source of data and methods:</u>

The state of exploitation was assessed for the period 2002-2008 by means of a VPA Separable, tuned with standardised CPUE from abundance indices from trawl survey (MEDITS). Analysis was carried out applying the Extended Survivor Analysis (XSA) method (Lowestoft suite; Darby and Flatman, 1994) over the period 2002-2008. In addition, a yield-per-recruit (Y/R) analysis (VIT program; Lleonart and Salat, 1992) was applied on the mean pseudo-cohorts 2002-2008 for the GFCM geographical sub-area Northern Spain (GSA-06). Both methods were performed from size composition of trawl catches (obtained from on board and on port monthly sampling) and official landings, transforming length data to age data by slicing (L2AGE program). The parameters of the size-weight relationship used in this assessment (García Rodriguez et al., 2003) are similar to those calculated by other authors (a= 0.0024; b= 2.464) (Ribeiro-Cascalho & Arrobas, 1987). The estimates made for the VBGF parameters (García Rodriguez et al., 2003) show also similar values ($L\infty$= 77; K= 0.38; t0=-0.065). The size composition of commercial landings were obtained by monthly length samplings carried out both in one of the ports (Santa Pola) as well as on board samplings, during the 2002-2008 period. Landings and effort data were obtained combining different sources, such as Official Landings provided by Autonomous Community, and from the Information and Sampling Network of the Spanish Oceanographic Institute (IEO).

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. SGMED-10-02 has no basis to provide specific managment advice. Management of the fisheries of blue and red shrimp need to consider the mixed fisheries interactions.

Short and medium term scenarios:
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Red shrimp (*Aristeus antennatus*) is one of the most important crustacean species for the trawl fisheries developed along the GFCM geographical sub-area Northern Spain (GSA 06). This resource is an important component of commercial landings in some ports of the Mediterranean Northern Spain, and is a target species of a specific trawl fleet. Updated information on landings and effort has been done on annual basis (2002-2008). Throughout the time series landings fluctuated between 300 and 650 tonnes, with an average of c.a. 500 tonnes. The red shrimp has a wide bathymetric distribution, between 80 and 3300 m depth (Sardà et al., 2005), and some areas may constitute a reservoir for the resource since they are located a long way from ports and in deeper zones up to 1000 m. Females predominate in the landings nearly 80% of the total. Discards of the red shrimp are null. The number of harbours with red shrimp fleets is 14 for the whole area. Exploitation is based on very young age classes, mainly 1 and 0 year old individuals, indicating a dependence on recruitments. Fishing effort has reduced from 20,000 days in 2002 to 9,000 in 2006, with a increase thereafter, reaching the 23,000 in 2008.

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
GSA 6 Landings (t)	645	647	347	316	320	470	638
Effort (days)	20874	26688	15152	14890	8942	17695	23718

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)	
F_{max} (age range)=	
Z_{max} (age range)=	
Z_{mean} (age range)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of blue and red shrimp in GSA 06 can be found in section 5.53 of this report.

A yield per Recruit analysis should be undertaken during the upcoming meetings of SGMED.

4.34. Giant red shrimp in GSAs 15 and 16

Species common name:	Giant red shrimp
Species scientific name:	*Aristaeomorpha foliacea*
Geographical Sub-area(s) GSA(s):	GSAs 15 and 16

Most recent state of the stock

Due to data constraints SGMED-10-02 did not update the stock assessment conducted in 2009 by SGMED-09-02. This section reiterates the findings in 2009 in order to facilitate regional overviews of stocks and fisheries' status and contributes to improved consistency regarding the scientific advice.

- State of the adult abundance and biomass:

Absolute levels of stock abundance in 2006, 2007 and 2008 were estimated using the VIT approach on length structure of Sicilian trawlers which catch about 98% of the total yield in the area. Mean total biomass ranges between 1,721 t (2008) and 1,883 t (2006), being SSB about 75% of the total stock biomass. Survey indices (MEDITS) combining GSAs indicate the stock to vary without an evident trend since 2002. However, the abundance and biomass of giant red shrimp consistently increased in both GSAs since 2007. SGMED-10-02 cannot fully evaluate the state of the SSB due to the lack of precautionary management references.

- State of the juvenile (recruits):

Absolute estimate of recruitment (18-22 mm CL) from VIT ranged between 63 (2008) and 95 (2007) millions of recruits. A low variability in recruitment indices derived from SURBA was observed when combining GSA data from 2002 to 2007, with the exception of sudden fall in recruit density observed in 2006 both in GSAs 15 and 16. The stability of recruitment indices in the last years is also confirmed by the analysis of the longer series from GSA 16.

- State of exploitation:

SGMED-10-02 proposes $F_{0.1}$=0.35 (average if both applied methods) as limit management reference point of exploitation consistent with high long term yield. The giant red shrimp in the Northern sector of the Strait of Sicily is considered overfished until 2008 since the current fishing mortality is significantly higher than both F_{max} and $F_{0.1}$. SGMED-10-02 recommends fishing mortality to be reduced by about 50% in order to avoid significant long term loss in potential yield. This should be realized by a multi-annual management plan reducing the fishing effort accordingly. It is advised to estimate the landings in accordance with the effort reductions.

- Source of data and methods:

Data derived both from indirect (fisheries monitoring) and direct (scientific surveys) sources. Stock status was assessed by using Y and SSB per recruit analysis with package VIT and Yield on females, which reach larger size and represents more than 60% of the landing in weight. Current F was assessed with steady state VPA with VIT by length and by age on LFD of 2006, 2007 and 2008 landings. Further estimations of F, SSB and recruitment indices derived from the SURBA software program was used to analyse the MEDITS time series. Biological parameters used were: K=0.61; Linf = 68.9 cm; t_0 = -0.2. M-at-age vector (PROBIOM sheet): 0.62; 0.30; 0.23; 0.19; 0.17; 0.16. q vector = estimate: q(Age0)=0.4; q(Age1+)=1.0; q(Age2+)=1.0; q(Age3+);tq(Age4+)=1.0. F_{max} and $F_{0.1}$ was estimated by VIT, with vector M by size (PROBIOM sheet) and Yield package (2000 runs) with scalar M=0 .42. No 2009 fisheries data were submitted by the Italian authorities.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Assuming status quo exploitation in 2009 SGMED recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed $F_{0.1}$ level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

SGMED-09-02 noted that the Italian government is adopting a management plan, in which a reduction of fishing mortality of 25% is planned within 2013. SGMED-08-04 was informed that medium term management plan for 2008-2013 has been agreed for Italian trawlers catching hake in GSA 15 and 16. The effect of 5 different management scenarios considered by the Italian Management Fishery Plans were:

- a fleet reduction of 25% of the current capacity obtained in two steps. The first (12.5%) from 2008 to 2010, and the second (12.5%) from 2011 to 2013;
- trawling ban of 45 days per year between January and March (targeted to deep water pink shrimp fishery which is the main commercial species in the GSA 15 and 16);
- changing the mesh opening in the cod-end from the 40 mm to 50 mm (diamond) from 2010;
- the above three measures combined; and
- maintaining the status quo.

Although designed mainly for deep water pink shrimps, the adoption of the management measures of the IFMP is expected to improve also the stock status of giant red shrimp in the area.

<u>Short and medium term scenarios:</u>
In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

The giant red shrimps is a relevant target species of the Sicilian and Maltese trawlers and is caught on the slope ground during all year round, but landing peaks are observed in summer. Yield of the Italian trawlers in 2006 was about 1424 t decreasing to 1260 t in 2008. The Maltese trawlers landed 25 t in 2006 and 34 t in 2007. *A.foliacea* is fished exclusively by otter trawl, mainly in the central –eastern side of the Strait of Sicily, whereas in the western side it is substitute by the red shrimp, *Aristeus antennatus.* Due to reduction of catch rate since 2004 some distant trawlers based in Mazara del Vallo, which is the main fleet in the area, moved to the eastern Mediterranean (Aegean and Levant Sea) to fish red shrimps.

Landings (t) by year and major gear types, 2005-2008 as reported through DCR.

Species	Area	Country	Fleet	2005	2006	2007	2008
ARS	15	Malta	OTB	17	26	34	27
ARS	16	Italy	OTB	1270	1424	1540	1260
ARS	15 & 16		OTB	1287	1450	1574	1287

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)	≤0.35
F_{max} (age range)=	
Z_{max} (age range)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of giant red shrimp in GSAs 15 and 16 can be found in section 5.59 of this report.

4.35. Norway lobster in GSA 05

Species common name:	Norway lobster
Species scientific name:	*Nephrops norvegicus* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 05

Most recent state of the stock

- State of the adult abundance and biomass:

SSB increased over the years 2002, 2005 and 2009, from the beginning of the data series (around 7 t) to the most recent years (around 12 t). In the absence of proposed and agreed precautionary management reference points SGMED is unable to fully evaluate the state of the stock.

- State of the juveniles (recruits):

Number of recruits for the years 2002, 2005 and 2009 were estimated to be rather constant with around 1 million individuals for the three years analysed.

- State of exploitation:

SGMED-10-02 recommends $F_{0.1}$=0.42 as limit management reference point consistent with high long term yields. The F_{ref} (0.62) exceeds the Y/R $F_{0.1}$ reference point (0.42), which indicates that Norway lobster in GSA 05 is overexploited in the long term.

- Source of data and methods:

Landings time series from 2000 to 2009 from all fishing ports of Mallorca. Length frequency distributions from on board monthly samplings developed during the entire time series. The biological parameters used for the assessment were those used during SGMED-09-02 for Norway lobster in GSA 09, as in the Spanish National Data Collection this species was not a target species until 2009 and then at this moment there are not available parameters for this species in GSA 05. Natural mortality at age was calculated using PROBIOM spreadsheet (Abella et al., 1997). Terminal fishing mortality (Ft) was obtained from the catch curve, using the FLEDA package (Jardim & Azevedo, 2004).

Outlook and management advice

SGMED-10-02 recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

Short, medium and long term scenarios:
To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

Norway lobster catches from the Balearic fleet comes exclusively from bottom trawl. The species is mostly caught in the upper slope (US, 350-600 m). Annual landings vary among 15 and 33 t. The mean annual number of days in which the fleet works in this fishing tactic (alone or in combination with other fishing tactics) is around 1050 days. Other species caught on the US are *Merluccius merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* (Guijarro and Massutí, 2006). Discards on the US have been estimated up to 18% (autumn) and 45% (spring) of captured biomass and they are composed by a large number of elasmobranchs, teleosts, crustaceans and cephalopods, among others.

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (2-5)	≤0.42
F_{max} (age range)=	
Z_{max} (age range)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of Norway lobster in GSA 05 can be found in section 5.61 of this report.

4.36. Norway lobster in GSA 09

Species common name:	Norway lobster
Species scientific name:	*Nephrops norvegicus* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

- State of the adult abundance and biomass:

Relative spawning stock biomass (SSB) indices derived from MEDITS (1994-2009) and GRUND (1994-2006) showed fluctuations without a particular trend in the spawning stock biomass (SSB). However, both indices of abundance and biomass in 2009 represent the maximum values since 1994. SGMED-10-02 cannot fully evaluate the state of the SSB due to a lack of precautionary management reference points.

- State of the juveniles (recruits):

Recruitment (age groups 1+ and 2+) showed a significant increasing trend since 1994.

- State of exploitation:

SGMED-10-02 proposes the estimated $F_{0.1}$ =0.21 as limit management reference point for sustainable exploitation consistent with high long term yield. Recent values of F_{3-7} obtained on commercial data with LCA (VIT) and using SURBA indicate that the stock is currently overexploited.

- Source of data and methods:

Medits survey data were available from 1994. A check of hauls allocation between GSA 09 and 10 needs to be done before calculation of indices from JRC MEDITS database. Landings data for 2009 were not available during SGMED-10-02, while effort data seem not consistent with previous estimates for the GSA. Due to lack of numbers-at-age or numbers-at-length from the landings the update of the assessment in 2009 was therefore not carried out.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Norway lobster is one of the most important commercial species in the GSA as total annual landing value. All the landing is due to bottom trawl vessels exploiting slope muddy bottoms mainly between 300 and 500 m depth. Catch of vessels targeting Norway lobster is composed of a mix of both commercial (hake, deep-sea pink shrimp, horned octopus (*Eledone cirrhosa*), squids (*Todaropsis eblanae*)), and non-commercial species. The trawl fleet of GSA 09 at the end of 2007 accounted for 360 trawlers. To date about 80-100 trawlers are involved in this fishery. In the last three years the total landings of Norway lobster of GSA 09 fluctuated between 228 (2008) to 260 tons (2007). The catch is mainly composed by adult individuals over the size-at-maturity and discarding of specimens under MLS (20 mm CL) is negligible.

Annual landings (t) by year and major gear types, 2006-2008 as reported through DCR.

YEAR	2006	2007	2008
DTS	247.96	260.55	227.67
GNS	0.09		0.06
Traps			0.05
Total	248.05	260.55	227.79

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (2-7)	≤0.21
F_{max} (age range)=	
Z_{max} (age range)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of Norway lobster in GSA 09 can be found in section 5.62 of this report.

4.37. Striped red mullet in GSA 05

Species common name:	Striped red mullet
Species scientific name:	*Mullus surmuletus*
Geographical Sub-area(s) GSA(s):	GSA 05

Most recent state of the stock

- State of the adult abundance and biomass:

SSB and stock biomass consistently declined over the time series since 2000 to the lowest value of the time series in 2009. In the absence of proposed and agreed precautionary reference points SGMED is unable to fully evaluate the state of the SSB.

- State of the juvenile (recruits):

Recruitment showed a clear decreasing trend along the series; the number of recruits decreased from 9 to $5 \cdot 10^6$ between 2000 and 2008. Also the 2009 recruitment is estimated at a low level, consistently with the survey information.

- State of exploitation:

SGMED-10-02 recommend $F_{0.1}$=0.288 as limit management reference point consistent with high long term yield. The F_{ref} (0.759) in 2009 is above the Y/R $F_{0.1}$ reference point (0.288), which indicates that striped red mullet in GSA 05 is overexploited.

- Source of data and methods:

Landings time series from 2000 to 2009 of the two fleets exploiting this species (trawl and small-scale fleet). Length frequency distributions from monthly on port (small-scale) and on board (trawling) samplings developed during the entire time series. The biological parameters used for the assessment were the following: 1) growth parameters obtained from otholit readings carried out in the framework of the Spanish National Data Collection (L_{inf}= 40.05, K= 0.164, t_0= S1.883); 2) length-weight relationships obtained from the Spanish National Data Collection (a= 0.0084, b= 3.118); 3) natural mortality at age calculated using the PROBIOM spreadsheet (Abella et al. 1997); and 4) maturity at age obtained from the Spanish National Data Collection in GSA 5.

XSA tuning were performed using abuncance indices from MEDITS surveys (N/km^2) developed during 2001–2009 around the Balearic Islands and CPUEs of daily landings from the trawling fleet of one port of Mallorca (Santanyí). It was used this port, situated in the SE of the island, because its fleet works basically on the continental shelf, and thus it can be considered that their CPUEs are a good indicator of the species abundance (*Mullus surmuletus* inhabits mainly on the shelf). The landings of this port represented 12–30% of the total catch of Mallorca during the assessed period. Abundance indices from surveys were calculated considering different bathymetric strata. For tuning VPA, the values obtained in the stratum corresponding to the continental shelf (<100 m depth) were used because they best reflected the evolution of commercial landings.

Outlook and management advice

SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated. A part of the catches is under the minimum landing size. In this sense, the improvement of the trawl exploitation patterns imply further increases in potential landings.

Short and medium term scenarios:

To be conducted and delivered by SGMED 10-03 (13-17 December 2010).

Fisheries

Striped red mullet is one of the most important target species in the trawl fishery developed by around 35-40 vessels off Mallorca (Balearic Islands, GFCM GSA5). A fraction of the small-scale fleet (~100 boats) also directs to this species during the second semester of the year, using both trammel nets and gillnets. During the last decade, the annual landings of this species have oscillated between 73-117 and 16-29 tons in the trawl and small-scale fishery, respectively.

Landings (in tons) as reported through the official 2010 DCF data call.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUR	5	ESP	OTB	DEMSP	40D50	130	101	100	117	108	132	98	91

Limit and target management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (1-5)=	≤0.28
F_{max} (1-5)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

E_{lim} (age range)=	
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of striped red mullet in GSA 05 can be found in section 5.68 of this report.

4.38. Common pandora in GSA 09

Species common name:	Common pandora
Species scientific name:	*Pagellus erythrinus* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 09

Most recent state of the stock

- State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the SSB. The index of stock abundance from MEDITS survey shows high variability throughout the time series, but no statistical significant trend is observed.

- State of the juveniles (recruits):

Recruitment shows no particular trend since 1994 and 2009, with a peak in 2005. The analysed data are believed to represents an underestimate of the numbers per km^2 because many juveniles are concentrated in very shallow waters poorly covered by the surveys.

- State of exploitation:

SGMED-10-02 proposed $F_{0.1}$=0.13 as limit management reference point of exploitation consistent with high long term yields. The stock can be considered overexploited. In relation to historic values, the abundance of the species is stable as demonstrated by the analysis of commercial LPUE's in the landings in the main ports of the area and from trawl surveys abundance indices. Available data is limited and do not allow a more detailed and precise assessment of the stock status. SGMED-10-02 concludes that the common pandora stock in GSA 09 is overfished and a reduction of F of about 50% is required. This will likely drive the stock biomass close to the B_{MSY} level.

- Source of data and methods:

Available data is limited and do not allow a more detailed and precise assessment of the stock status. SEINE software (Survival Estimation in non-equilibrium situations) (Gedamke and Hoenig, 2006) was used for the estimation of Z, using weighted information of mean size of catch, size of full capture and growth parameters. In this study, the transitional behaviour of the mean length statistic is derived for use in nonequilibrium conditions. This new non-equilibrium estimator allows a change in mortality to be characterized reliably several years faster than would occur with the use of the Beverton–Holt estimator.
A traditional Beverton & Holt Y/R analysis was performed with the "Yield" software.

Outlook and management advice

Due to constraints in data availability SGMED-10-02 is unable to estimate most recent (2009) stock parameters. Based on available information and assuming status quo exploitation in 2009 SGMED-10-02 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the effort reductions should be estimated.

Short and medium term scenarios:

In the absence of updated catch information and assessments SGMED will be unable to accomplish short term predictions of catch and stock biomass for 2010 and 2011.

Fisheries

Pagellus erythrinus is caught as a part of a species mix that constitutes the target of the trawlers operating near shore. The main commercial species in this mix in GSA 9 are *Squilla mantis, Sepia officinalis, Trigla lucerna, Merluccius merluccius, Mullus barbatus, Gobius niger.* Fishing effort has shown a moderate decline in the analyzed period. The species is mainly caught in late summer-beginnings of autumn. Size of full capture is about 8 cm. Catch is mainly composed by age 0 and 1 individuals while the older age classes are poorly represented. Catch rates remained almost stable along the study period. No dramatic changes occurred on effort allocation nor on other aspects of fishing behaviour in the analyzed years and thus a steady state of the stock abundance as suggested by trawl surveys data can be hypothesized. Even if catch within the coastal 3 miles is forbidden, illegal fishing do occur producing an unknown amount of fishing mortality on juveniles of the species. The main concentrations of older individuals are positioned at higher depths than juveniles and often over relatively hard bottoms and not trawlable areas. Set nets catch modest quantitatives of relatively large individuals. The exerted fishing pressure on this species on different zones of GSA 9 is quite variable as it is affected by the composition of that part of the fleet operating close to their respective ports, by the characteristics of the bottom that are potentially exploitable and are close to the ports and also by differences in the target species of the fisheries among fleets and zones. No discard data were available to SGMED-10-02.

Landings by fishing technique as reported through the official 2010 DCF data call. No 2009 data were submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
PAC	9	ITA							1	1			
PAC	9	ITA	GNS	DEMSP				154	121	89	123	66	
PAC	9	ITA	GNS	SLPF					0			0	
PAC	9	ITA	GTR	DEMSP				76	73	71	19	47	
PAC	9	ITA	LLD	LPF					0	3			
PAC	9	ITA	LLS	DEMF					3	1	1		
PAC	9	ITA	OTB	DEMSP				79	31	34	40	95	
PAC	9	ITA	OTB	MDDWSP				103	164	91	87	8	
PAC	9	ITA	PS	SPF				0					
Sum								412	393	290	270	216	

Fisheries management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)	≤0.13
F_{max} (age range)=	
Z_{max} (age range)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of common pandora in GSA 09 can be found in section 5.70 of this report.

5. DETAILED STOCK ASSESSMENTS

5.1. Introductory notes

SGMED-10-02 presents the following stock assessment approaches in an agreed and consistent format in order to allow scientists and fisheries managers a quick review of all information provided, the methods used and the assessment results.

Constrained by data availability and the fact, that the framework of SGMED has just been created in 2008, not all the assessments presented are considered final. SGMED will continue to improve and update the assessments in the future, especially where data or scientific advice with respect to precautionary and limit references of stock size and exploitaiton is lacking.

In some assessments, SGMED applied a number of different approaches in order to verify the assessment results. The assessment tools applied are CPUE analyses from surveys, hydro-acoustic surveys, daily egg productions, virtual population analyses (XSA or ICA) calibrated with survey or commercial data on stock abundance, pseudo-cohort analyses (VIT) and various dynamic production models under equilibrium (YpR) or non-equilibrium conditions (ALADYM, ASPIC). Different software was identified and used for the analyses conducted.

The assessments are largely based on data obtained through the DCR (until 2008) and DCF (2009) and the official call issued in 2010 for fisheries and scientific survey data (published on the STECF homepage https://datacollection.jrc.ec.europa.eu/), also covering data collected during national programmes or projects co-funded by the EU-Commission. SGMED was often unable to verify the origin or quality of the data used in the assessment but will continue its effort to validate the data through expert knowledge and transparent presentation of the data.

Inconsistent, late or lack of data submissions again significantly hampered the accomplishment of SGMED's tasks. Major drawbacks were missing fisheries data for 2009 from Italy, Greece and Cyprus, which impeded updates and assessments of most recent parameters of many exploited stocks in the relevant GSAs. Such cases are clearly identified in the following assessment sections which include other data updates as available and appropriate in order to facilitate and promote future assessments. SGMED-10-02 acknowledges the various contributions of Spanish and French experts which resulted in major improvements of the relevant stock assessments and derived scientific advice.

In accordance with the ToRs, this SGMED-10-02 report deals with assessment of historic and recent trends in stock parameters (stock size, recruitment and exploitation) and relevant scientific fisheries management advice. SGMED-10-02 represents 69 stock assessment approaches with relevant data for European hake (*Merluccius merluccius*, 14 stocks), red mullet (*Mullus barbatus*, 15 stocks), striped mullet (*Mullus surmuletus*, 2 stocks), common Pandora (*Pagellus erythrinus*, 1 stock), common sole (*Solea solea*, 1 stock), anchovy (*Engraulis encrasicolus*, 6 stocks), sardine (*Sardina pilchardus*, 5 stocks), pink shrimp (*Parapenaeus longirostris*, 10 stocks), blue and red shrimp (*Aristeus antennatus*, 4 stocks), giant red shrimp (*Aristaeomorpha foliacea*, 4 stocks), and Norway lobster (*Nephrops norvegicus*, 7 stocks).

Where exploitation rates or coefficients of exploitation rates (fishing mortality) could be analytically assessed, fisheries management advice consistent with high long term yields is formulated conditional of proposed reference points (F_{MSY} or $F_{0.1}$).

Deterministic short and medium term predictions of stock size and catches (landings) under various management options as well as relevant scientific advice will we delivered through the forthcoming SGMED-10-03 meeting (13-17 December 2010).

5.2. Stock assessment of hake in GSA 01

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.2.1. Stock identification and biological features

5.2.1.1. Stock Identification

The delimitation of the hake stock in GSA01 is considered unknown. Likely connections with hake in GSA06 may exist, because of the continuity of shelf. Large exchanges with the south Alborán Sea (GSA03) are believed insignificant.

5.2.1.2. Growth

Two growth parameter sets were considered: fast and slow. Also different values were used for males and females. They are shown in Table 5.2.1.2.1.

Tab. 5.2.1.2.1. Two sets of growth parameters (v. Bertalanffy) by sex for hake in GSA 01.

	Fast growth Females	Fast growth Males	Slow growth Females	Slow growth Males	Units
Linf	100.7	72.8	100.7	72.8	cm
K	0.248	0.298	0.124	0.149	$year^{-1}$
t0	-0.35	-0.383	-0.35	-0.383	year
a	0.0069	0.0069	0.0069	0.0069	
b	3.03	3.03	3.03	3.03	
M	0.18	0.22	0.18	0.22	$year^{-1}$

5.2.1.3. Maturity

Fig. 5.2.1.3.1 shows the maturity at length ogive for female hake in GSAs 01, 05 and 06. The more recent years indicate significant reduction in size at maturation.

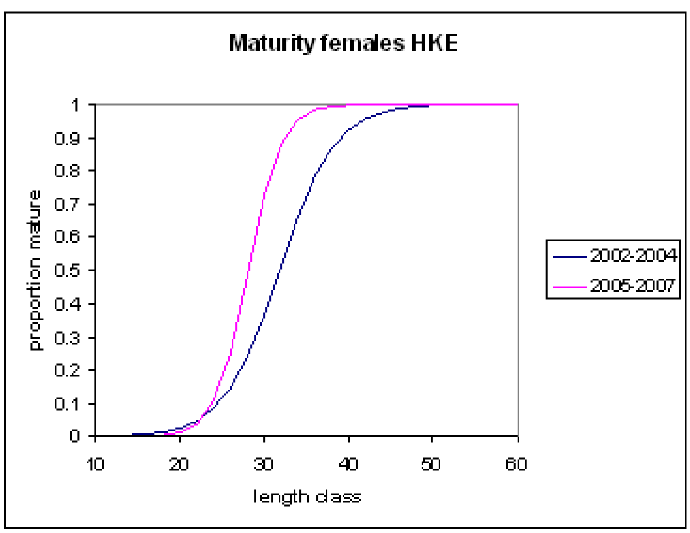
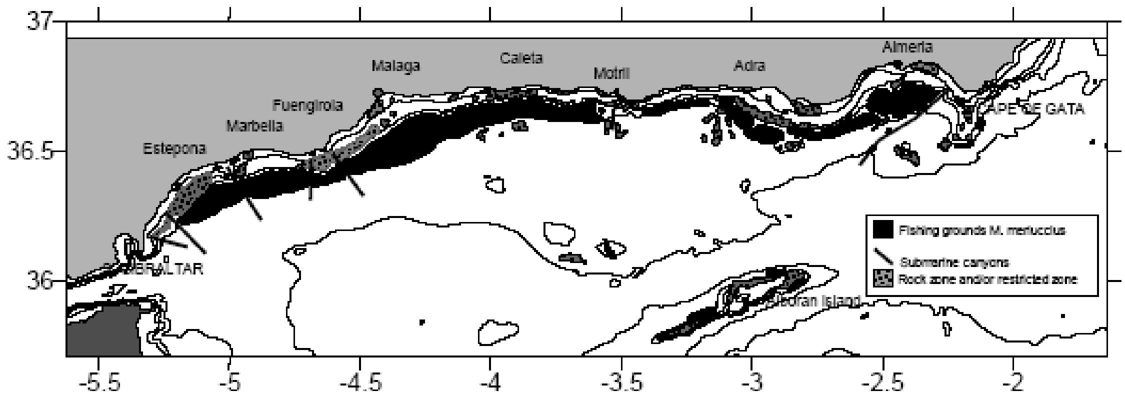


Fig. 5.2.1.3.1 Maturity ogives for female hake in GSAs 01, 05 and 06.

5.2.2. Fisheries

5.2.2.1. General description of fisheries

Hake is one of the most important target species for the trawl fisheries in GSA 01. It is exploited in all trawlable areas from Gibraltar straight to Cape of Gata, including the deep-bottom fishing grounds around GSA 02. Commonly small hakes are caught in shallow waters about 50 m to 300 m depth, whereas adults reach the maximum depths exploited (800 m), associated with the red shrimp (*Aristeus antennatus*) fishery.



Fishing grounds M. Merluccius in GSA 1 **(**Source: I.E.O.**)**

Fig. 5.2.2.1.1 Fishing grounds of hake in GSA 01. Countries: only Spain

5.2.2.2. Management regulations applicable in 2009 and 2010

No information was documented.

5.2.2.3. Catches

5.2.2.3.1. Landings

Tab. 5.2.2.3.1.1 shows the trend in reported landings taken by trawlers (Spain only). The data were reported to SGMED-10-02 through the Data collection framework.

Tab. 5.2.2.3.1.1 Annual hake landings (t) by Spanish trawlers.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	1	ESP	OTB	DEMSP	40D50	353	201	374	208	212	220	242	489

Annual lengths of landings were reported to SGMED-09-02 only for 2005-2008 and are shown in Fig. 5.2.2.3.1.1.

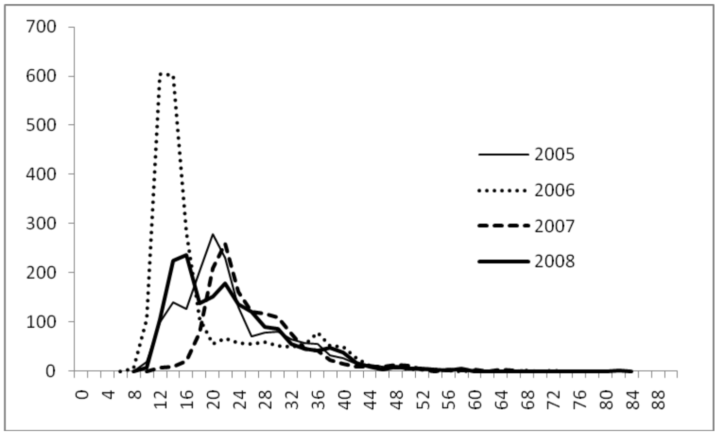


Fig. 5.2.2.3.1.1 Annual size composition of hake landings (thousands) by Spanish trawlers, 2005-2008.

5.2.2.3.2. Discards

SGMED-09-02 received discard data only for 2005 and 2008. A total of 6 tons discarded in 2005 and 16 tons for 2008 (2.9% and 6.6% of the landings, respectively).

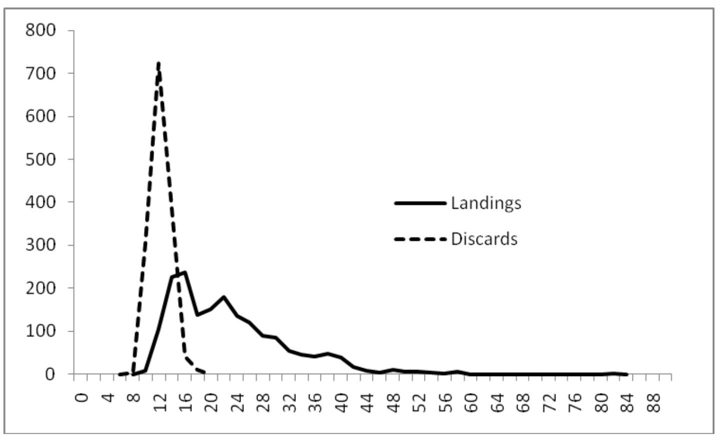


Fig. 5.2.2.3.2.1 Annual size composition of hake landings and discards (thousands) by Spanish trawlers, in 2008.

5.2.2.3.3. Fishing effort

No effort data were reported to SGMED-10-02 through the DCF data call for Spain.

5.2.3. Scientific surveys

5.2.3.1. Medits

5.2.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were calculated. In GSA 01 the following number of hauls were reported per depth stratum (s. Tab. 5.2.3.1.1.1)

Tab. 5.2.3.1.1.1. Number of hauls per year and depth stratum in GSA 01, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA01_010-050	2	1	2	2	2	2	2	3	3	3	3	2	3	3	4	2
GSA01_050-100	5	4	5	5	5	7	6	4	6	10	7	7	6	6	6	7
GSA01_100-200	3	3	3	5	5	5	5	4	8	6	5	6	5	6	6	6
GSA01_200-500	7	9	11	10	7	11	12	10	11	11	13	11	11	11	11	11
GSA01_500-800	6	9	12	10	12	12	9	13	13	14	13	11	15	10	7	5

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al., 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.2.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.2.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 01 was derived from the international survey Medits. Figure 5.2.3.1.3.1 displays the estimated trend in hake abundance and biomass for the GSA 01.

It can be seen in the following figures, that the Medits indices for hake in GSA 01 do not follow the general increasing trend but appear to having recently increased from a very low to an average level estimated since 1994 (Fig. 5.2.3.1.3.1). The biomass index even reaches the maximum level observed since 1994.

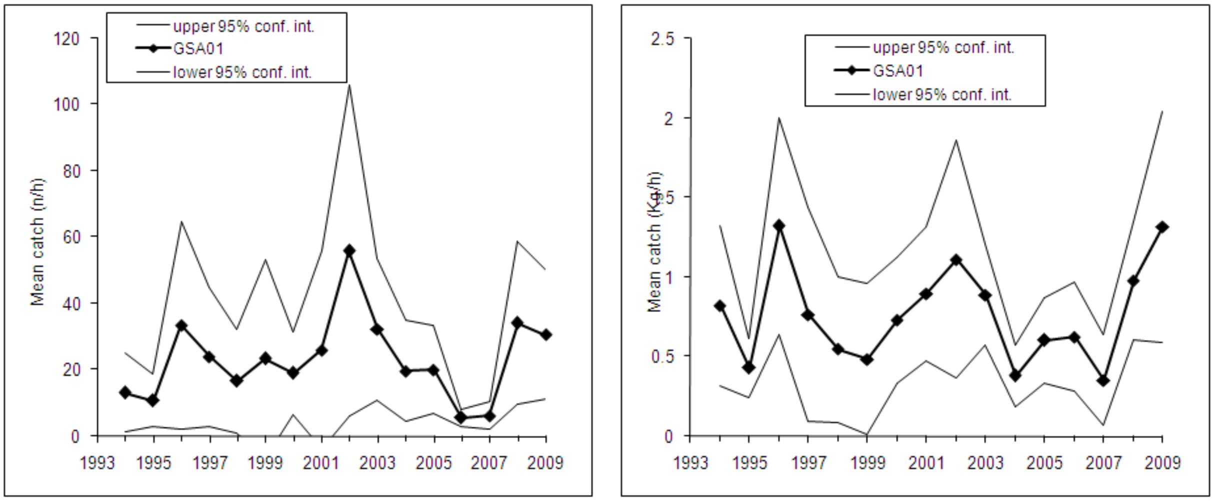


Fig. 5.2.3.1.3.1. Abundance and biomass indices of hake in GSA 01.

5.2.3.1.4. Trends in abundance by length or age

The following Fig. 5.2.3.1.4.1 and 2 display the stratified abundance indices of GSA 01 in 1994-2001 and 2002-2009. These size compositions are considered preliminary.

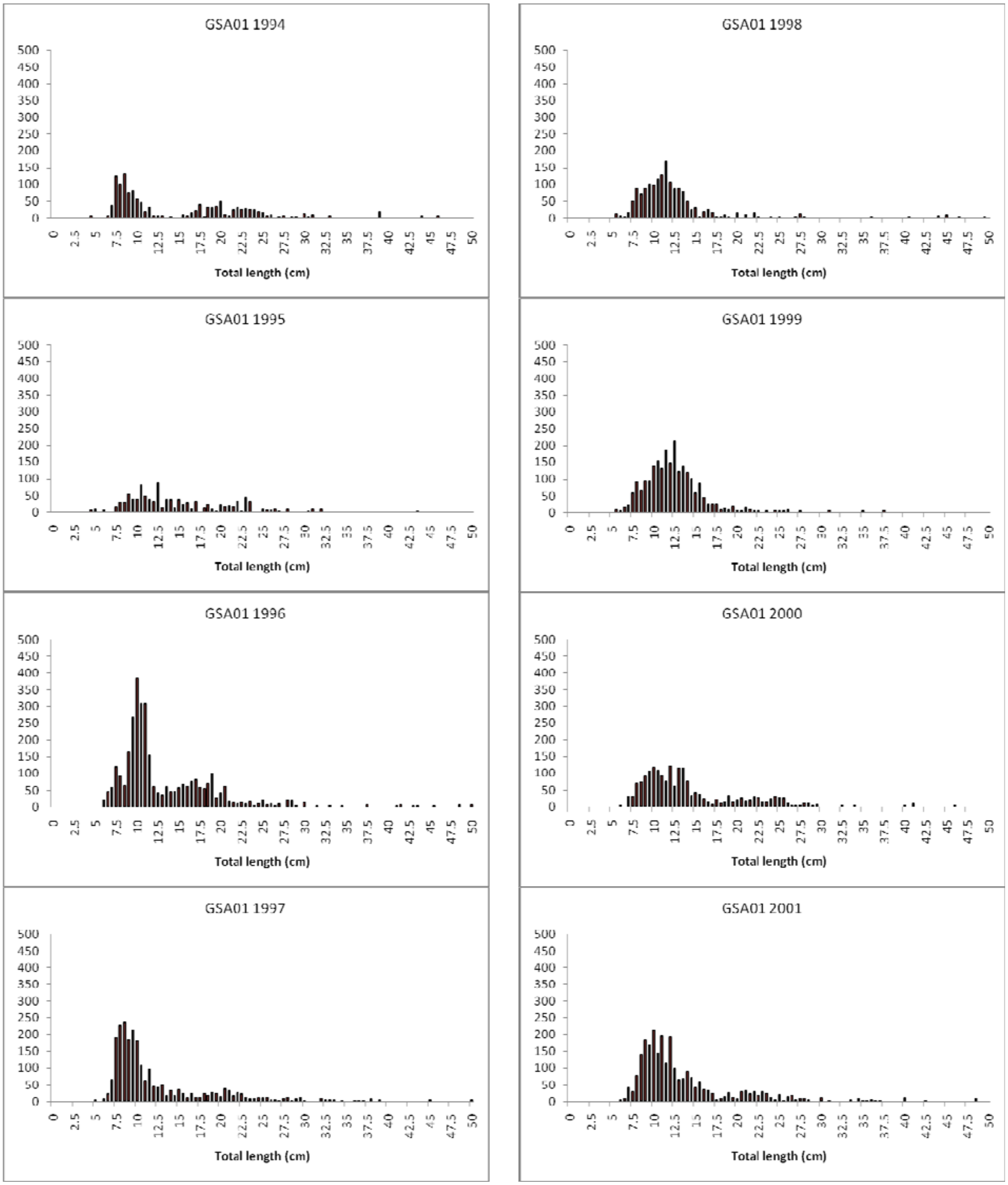


Fig. 5.2.3.1.4.1 Stratified abundance indices by size, 1994-2001.

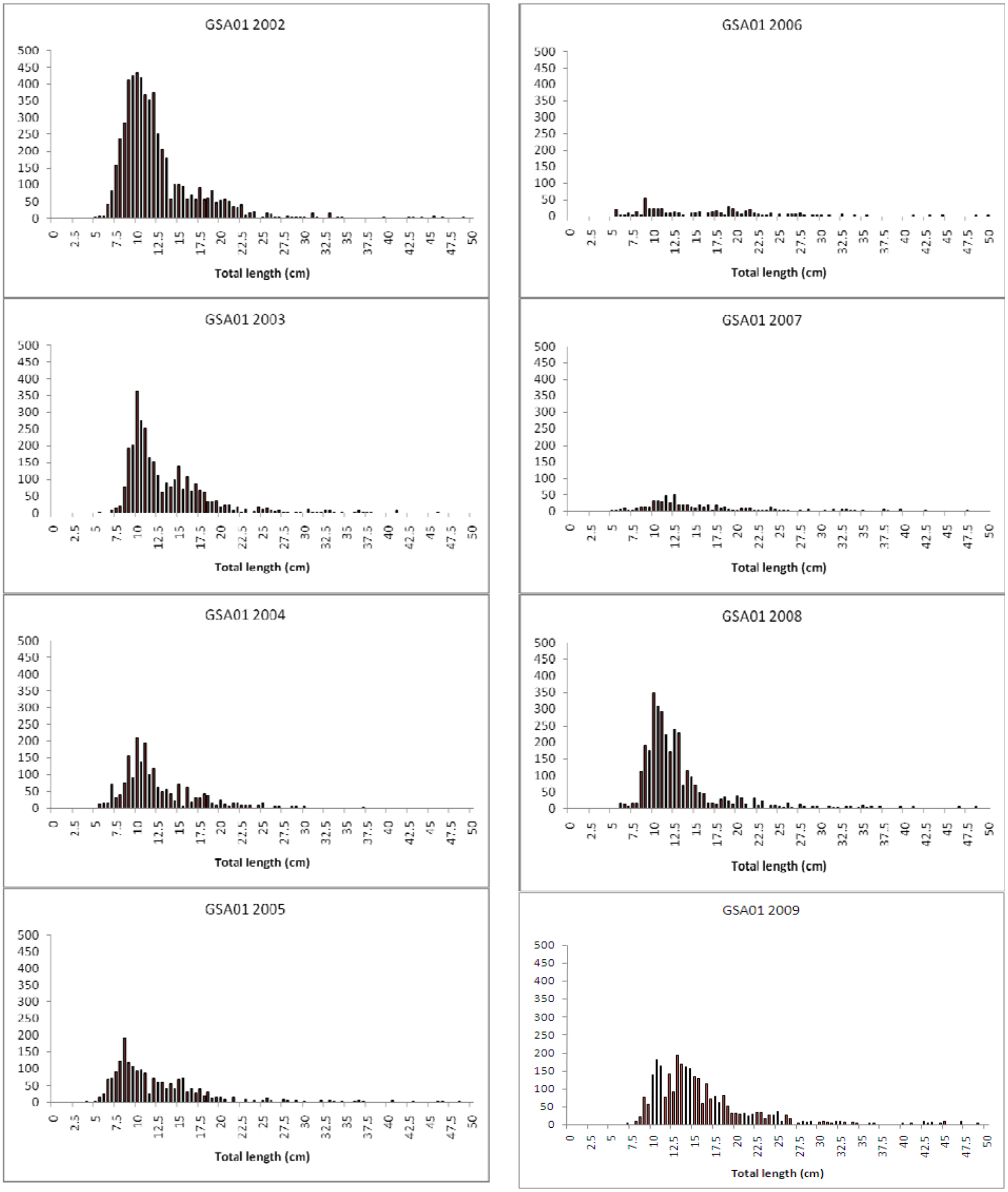


Fig. 5.2.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.2.3.1.5. Trends in growth

No analyses were conducted.

5.2.3.1.6. Trends in maturity

No analyses were conducted

5.2.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment of hake in GSA 01. The assessment carried out in 2008 using SURBA and VIT can be found in the report of SGMED-08-04 working group (Cardinale *et al*., 2008).

5.2.5. Long term prediction

5.2.5.1. Justification

No forecast analyses were conducted.

5.2.5.2. Input parameters

No forecast analyses were conducted.

5.2.5.3. Results

No forecast analyses were conducted.

5.2.6. Scientific advice

5.2.6.1. Short term considerations

5.2.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.2.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.2.6.1.3. State of exploitation

SGMED cannot estimate recent or historic exploitation rates. No proposed or agreed reference points were available to SGMED to identify stock status.

5.3. Stock assessment of hake in GSA 05

5.3.1. Stock identification and biological features

5.3.1.1. Stock Identification

Due to the lack of information about the structure of hake (*Merluccius merluccius*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 05 boundaries.

5.3.1.2. Growth

The following parameters, obtained in the framework of the Spanish Data Collection Program, were used (growth parameters obtained from otolith reading).

L_∞ =85 cm; k = 0.172; t_0= -0.177

Length-weight relationship: a = 0.0048; b = 3.12

5.3.1.3. Maturity

The maturity ogive used, obtained in the framework of the Spanish Data Collection Program, is presented in the following Table 5.3.1.3.1:

Table 5.3.1.3.1 Maturity ogive of hake in GSA 05, both sexes combined.

age (years)	0	1	2	3	4	5+
rel. mature	0	0.05	0.56	0.89	0.98	1

5.3.2. Fisheries

5.3.2.1. General description of fisheries

In the Balearic Islands (GSA 05), commercial trawlers employ up to four different fishing tactics (Palmer *et al.* 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Guijarro & Massutí 2006; Ordines *et al*. 2006). Vessels mainly target striped red mullet (*Mullus sumuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered monospecific.

5.3.2.2. Management regulations applicable in 2009 and 2010

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 HP: not fully observed
- Mesh size in the codend (diamond 40 mm stretched): fully observed
- Time at sea (12 hours per day and 5 days per week): fully observed
- Minimum landing size (EC regulation 1967/2006, 20 mm CL): mostly fully observed

5.3.2.3. Catches

5.3.2.3.1. Landings

Landings of hake in GSA 05 are exclusively provided by trawling. In the last 30 years they have presented important oscillations, with maximum values around 170 t and minimum of 40 t (Fig. 5.3.2.3.1.1).

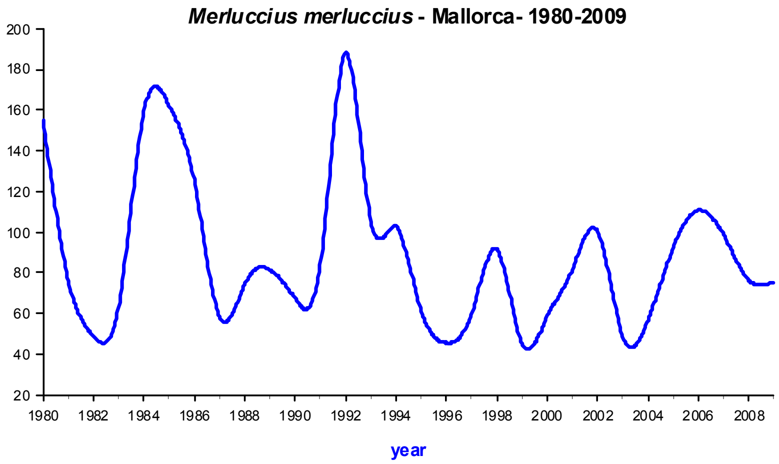


Fig. 5.3.2.3.1.1. Landings of hake (trawls) in GSA 05, from 1980 to 2009.

Tab 5.3.2.3.1.1 shows the trend in reported landings taken by trawlers (Spain only). The data were reported to SGMED-10-02 through the Data Collection Regulation. Since 2002 the annual landings varied between 44 and 102 t.

Tab. 5.3.2.3.1.1 Annual hake landings (t) by Spanish trawlers.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	5	ESP	OTB	DEMSP	40D50	91	44	57	86	102	72	68	71

Average length of hake catches is around 21 cm. Fig. 5.3.2.3.1.2 shows length frequency distributions (average) for three different decades.

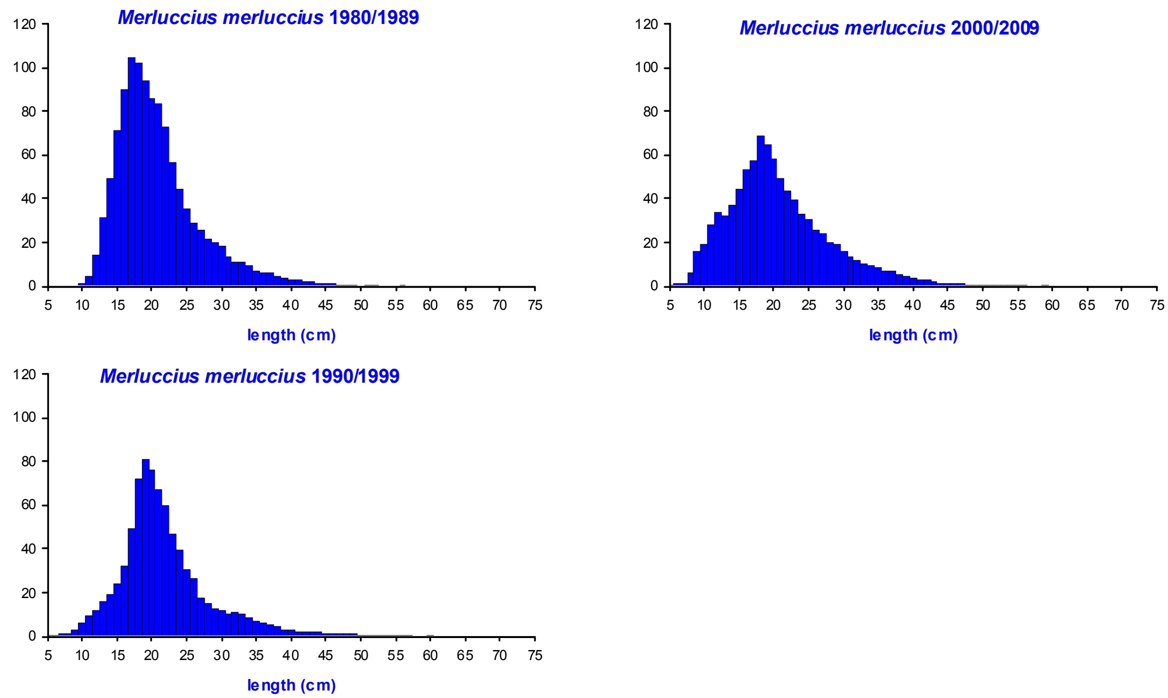


Fig. 5.3.2.3.1.2. Size structure of hake in 1980-1989, 1990-1999 and 2000-2009 (average) caught by otter trawling in GSA 05.

5.3.2.3.2. Discards

Although the level of discards of hake in GSA 05 is not very high, they are mostly composed by under-sized individuals and have been included in the assessment.

5.3.2.3.3. Fishing effort

There has been a progressive decrease in the number of trawlers from 1980 to 2009, from around 70 vessels to less than 40. However, given that Spain did not provide effort data on kW*days, no conclusion about the trend in nominal effort deployed can be drawn.

5.3.3. Scientific surveys

5.3.3.1. BALAR and MEDITS surveys

5.3.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 05 the following number of hauls were reported per depth stratum (s. Tab. 5.3.3.1.1.1)

Tab. 5.3.3.1.1.1. Number of hauls per year and depth stratum in GSA 05, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA05_050-100														8	7	7
GSA05_100-200		1				1		1			1		1	5	5	5
GSA05_200-500		4	2	2	2	1		5	2		2	2	4	6	5	6
GSA05_500-800	1	5	3	2	2	3	1	2	2		2	2	2	1	6	5

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

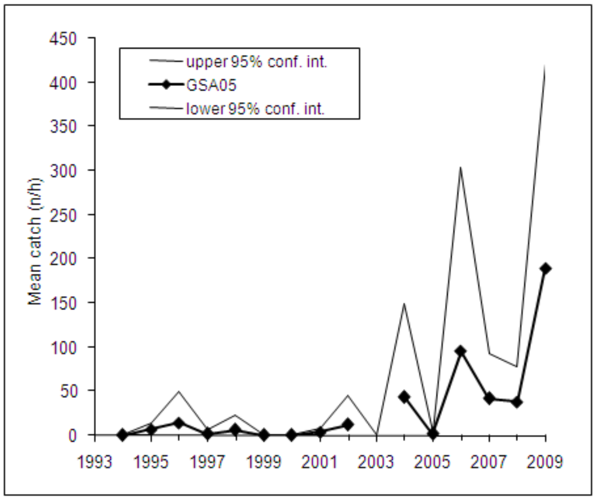
5.3.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.3.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 05 was derived from the international survey Medits. Figure 5.3.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 05.

The few hauls may indicate a general increasing trend in both abundance and biomass since 1994. However, SGMED-10-02 considers the high stock abundance estimates in 2009 as uncertain due to the high variation in the few hauls conducted. In addition, the survey coverage has recently changed in area GSA 05.



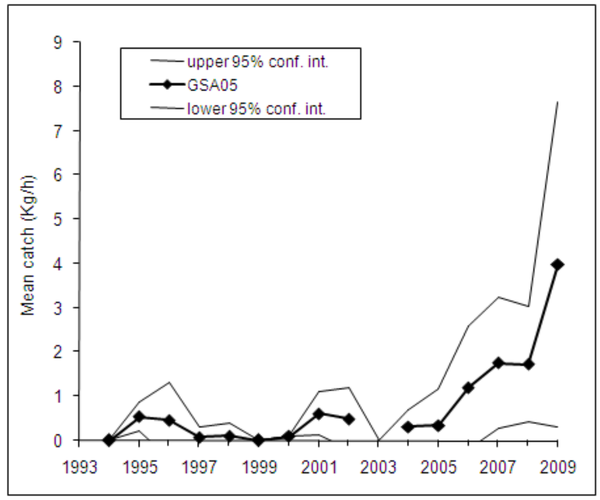


Fig. 5.3.3.1.3.1 Abundance and biomass indices of hake in GSA 05.

Fig. 5.3.3.1.3.2 shows the abundance (n/km^2) of hake from the BALAR and MEDITS surveys for the total population of hake, as well as the CPUE (kg hake/day/boat) of hake landed in the Port of Alcúdia (NE Mallorca). Both tuning time series fleets show a good correlation, with constant values at the beginning of the data series and a maximum in 2006.

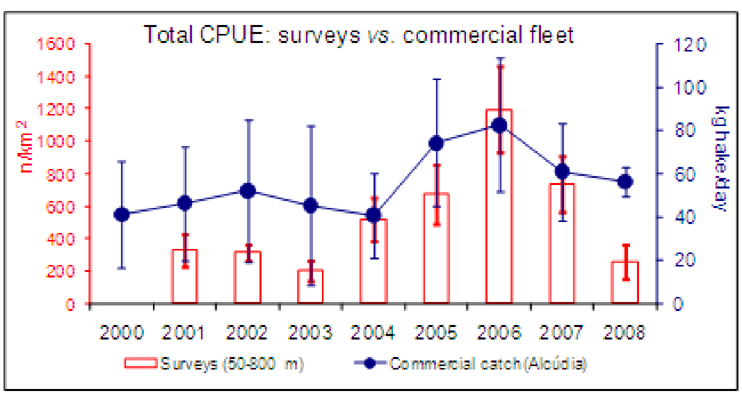


Fig. 5.3.3.1.3.2 Abundance of hake from the BALAR-MEDITS surveys and from the commercial fleet of Alcúdia.

5.3.3.1.4. Trends in abundance by length or age

The following Fig. 5.3.3.1.4.1 and 2 display the stratified abundance indices of GSA 05 in 1995-2004 and 2005-2009.

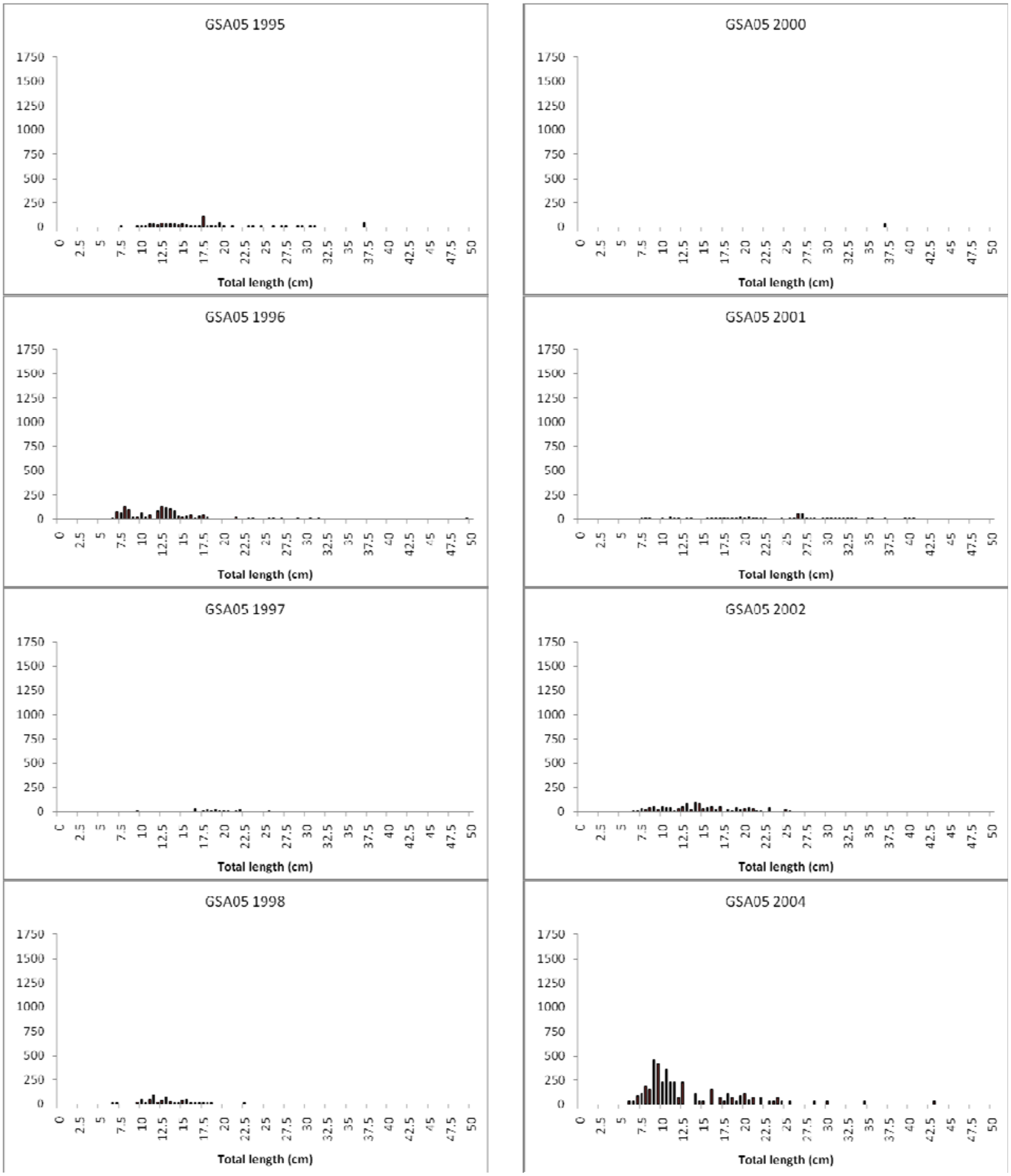


Fig. 5.3.3.1.4.1 Stratified abundance indices by size, 1995-2004.

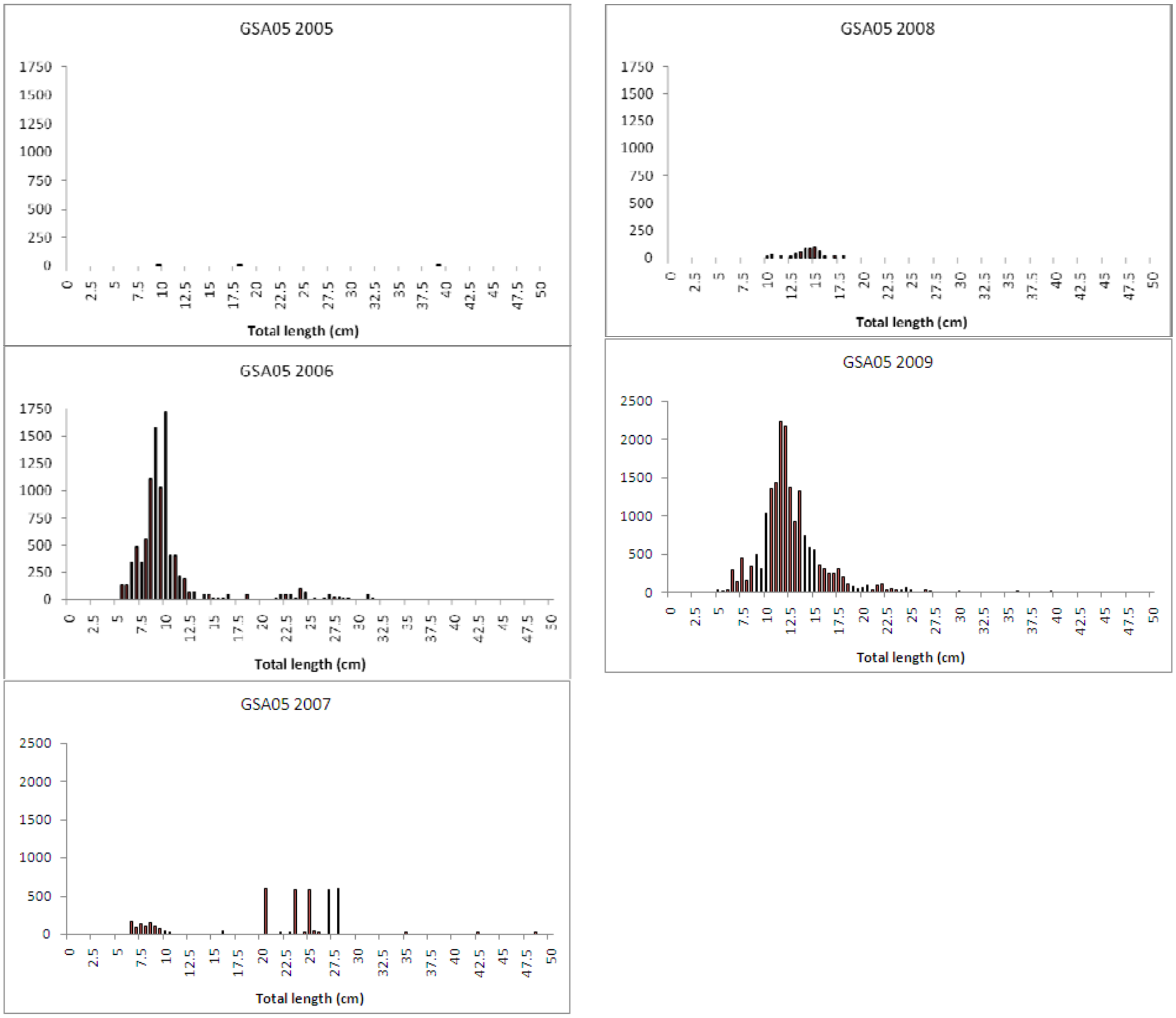


Fig. 5.3.3.1.4.2 Stratified abundance indices by size, 2005-2009.

5.3.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.3.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.3.4. Assessment of historic stock parameters

5.3.4.1. Method 1: XSA

5.3.4.1.1. Justification

XSA was used to assess the stock using two different tuning fleets: (i) fishery independent data (BALAR-MEDITS surveys) and (ii) commercial fleet of Port de Alcúdia. The software used was the Lowestoft suite (Darby and Flatman, 1994). A separable VPA (Pope and Sheperd, 1982) was also used as exploratory analysis.

5.3.4.1.2. *Input parameters*

Landings time series from 1980 to 2009 from the bottom trawl fleet of Mallorca. Length frequency distributions from monthly on board or on port samplings developed between 1980 and 2009 (Fig. 5.3.4.1.2.1).

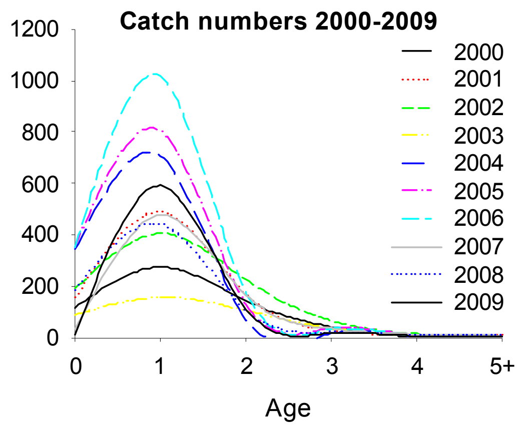


Fig. 5.3.4.1.2.1. Catch at age distributions of hake landed in the Balearic Islands for the last 10 years.

Table 5.3.4.1.2.1 Catch at age (thousands), 1980-2009.

	0	1	2	3	4	5+
1980	117.5	1020.4	297.2	48.5	15.6	2.4
1981	228.1	442.1	93.4	41.9	6.4	4.3
1982	70.3	287.6	83	20.1	2.2	2.7
1983	66.5	569.7	67.4	14.4	2.2	0.6
1984	365.6	1658.9	273.3	16.6	6.6	1
1985	468.8	1406.8	229.5	63.7	6.3	1.4
1986	21.4	1005.9	149	38.6	10	2.8
1987	6.7	402.8	78.1	15.9	4.2	2.2
1988	36.5	529.2	121.6	23.5	5.1	0.7
1989	38.6	814.3	97.4	19.4	2.4	1
1990	1.8	541.9	90.8	20.9	5.2	1.8
1991	0	419.4	106	37.4	10.2	6.9
1992	197.1	1641.7	245	32	9.8	9.6
1993	16.1	806	129.9	31.2	8.1	2.9
1994	15.7	788.4	127.1	30.5	7.9	2.8
1995	123.9	286.4	48.9	16.9	12.3	10
1996	34.8	193.5	32.4	15.3	8.4	8.9
1997	108.8	245.2	90.2	24.3	15.2	12.2
1998	177.7	531.8	194	57.2	6.2	3.3
1999	135.5	339.8	79.5	17.1	6.6	2.5
2000	117.5	274.5	143	41.7	2.8	2.6
2001	153.9	489.1	166.9	29.5	7.3	9.4
2002	189.9	405.6	224.5	65.5	13.8	4.4
2003	89	156.5	105.2	35.3	7.7	4.8
2004	341.6	708.1	68.5	17.1	2.7	1.5
2005	352.6	806	129.1	39.5	4	2.1
2006	352.9	1016.4	172.7	34.6	5.7	2.4
2007	29.9	476.6	165.8	34.8	12.6	6.5
2008	183.1	441.8	102.7	21.4	9	8.5
2009	11.5	591.3	109.7	19.8	4.5	4.8

The biological parameters used for the assessment, obtained in the framework of the Spanish Data Collection Program, were used. Natural mortality at age was calculated using the PROBIOM spreadsheet (Abella *et al*., 1997).

Growth parameters		
L_∞	k	t_0
85 cm	0.172	-0.177

Length-weight relationship	
a	b
0.0048	3.12

Maturity ogive					
0	1	2	3	4	5+
0	0.05	0.56	0.89	0.98	1

Natural mortality						
Age	0	1	2	3	4	5+
M	1	0.7	0.5	0.4	0.4	0.4

5.3.4.1.3. Results

Terminal fishing mortality (Ft) was obtained from the catch curve, using the FLEDA package (Jardim & Azevedo 2004).

Tab. 5.3.4.1.3.1 Regression statistics from the XSA diagnostics.

Age	Slope	t-value	Intercept	RSquare	N Points	Reg s.e	Mean Q
0	0.87	0.176	9.84	0.2	10	0.99	-10.09
1	0.63	1.181	7.25	0.59	10	0.31	-7.31
2	1.44	-0.735	7.95	0.27	10	0.49	-7.22
3	0.83	0.384	6.8	0.41	10	0.49	-7.36
4	1.92	-1.397	12.29	0.24	10	0.92	-7.63

Tab. 5.3.4.1.3.2 Fishing mortality estimated by XSA 1980-2009.

Table 8	Fishing mortality (F) at age									
YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
0	0.0709	0.179	0.0226	0.0127	0.085	0.1502	0.0124	0.0033	0.0134	0.0182
1	1.6241	1.0413	0.8637	0.5697	1.3692	1.6051	1.6813	0.7956	0.9445	1.2217
2	1.6013	1.1378	0.9861	0.8816	1.112	1.344	1.4602	0.9639	1.1051	0.7487
3	1.4937	2.0832	1.2568	0.6113	0.7907	1.3697	1.3768	0.8062	1.4498	0.7038
4	1.2292	1.139	0.7999	0.5285	0.8587	1.1462	1.1621	0.6555	0.899	0.6873
+gp	1.2292	1.139	0.7999	0.5285	0.8587	1.1462	1.1621	0.6555	0.899	0.6873
0 FBAR 0- 4	1.2038	1.116	0.7858	0.5208	0.8431	1.123	1.1386	0.6449	0.8824	0.6759
Table 8	Fishing mortality (F) at age									
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
0	0.0008	0	0.0661	0.0063	0.0146	0.0868	0.0219	0.0526	0.0939	0.0682
1	0.9249	0.5262	1.4999	1.0596	1.3076	0.9907	0.4022	0.4538	0.9612	0.5806
2	0.6659	0.7817	1.3358	0.697	0.7801	0.3636	0.4293	0.5457	1.7601	0.5796
3	0.47	0.9449	0.8235	0.8206	0.4637	0.2829	0.2423	0.996	1.2799	1.0946
4	0.525	0.5741	0.9538	0.6592	0.6547	0.4384	0.2777	0.5215	1.0494	0.5922
+gp	0.525	0.5741	0.9538	0.6592	0.6547	0.4384	0.2777	0.5215	1.0494	0.5922
0 FBAR 0- 4	0.5173	0.5654	0.9358	0.6485	0.6442	0.4325	0.2747	0.5139	1.0289	0.583
1										
Table 8	Fishing mortality (F) at age									
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
0	0.048	0.0927	0.1709	0.0332	0.108	0.1014	0.1844	0.017	0.0801	0.0144
1	0.4075	0.6513	0.9139	0.4454	0.9908	0.9934	1.2722	1.0215	0.8991	0.9938
2	0.9252	0.8149	1.4601	1.2243	0.5932	0.8267	1.0902	1.4417	1.1967	1.0768
3	1.0386	0.6784	1.4909	1.6896	0.9475	1.3182	0.7776	0.9785	1.0595	1.198
4	0.6648	0.6476	1.1315	0.9251	0.7012	0.8009	0.8896	1.0188	1.0235	0.8948
+gp	0.6648	0.6476	1.1315	0.9251	0.7012	0.8009	0.8896	1.0188	1.0235	0.8948
0 FBAR 0- 4	0.6168	0.577	1.0335	0.8635	0.6682	0.8081	0.8428	0.8955	0.8518	0.8356

Tab. 5.3.4.1.3.3 Population size at age estimated by XSA.

Table 10	Stock number at age (start of year)		Numbers*10**-3								
YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	
AGE											
0	2830	2294	5176	8691	7393	5540	2867	3351	4514	3528	
1	1803	970	706	1861	3157	2498	1754	1042	1229	1638	
2	478	177	170	148	523	399	249	162	233	237	
3	76	58	34	38	37	104	63	35	38	47	
4	27	11	5	7	14	11	18	11	11	6	
+gp	4	7	6	2	2	2	5	5	1	2	
0 TOTAL	5218	3518	6096	10747	11126	8555	4956	4606	6026	5459	
Table 10	Stock number at age (start of year)		Numbers*10**-3								
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
AGE											
0	3957	8152	5083	4195	1783	2458	2650	3501	3269	3387	
1	1274	1455	2999	1751	1534	646	829	954	1222	1095	
2	240	251	427	332	301	206	119	275	301	232	
3	68	75	70	68	100	84	87	47	97	31	
4	16	29	19	20	20	42	42	46	12	18	
+gp	5	19	18	7	7	34	44	36	6	7	
0 TOTAL	5560	9980	8617	6374	3745	3470	3772	4859	4906	4770	
1											
Table 10	Stock number at age (start of year)		Numbers*10**-3								
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE											
0	4136	2866	1993	4491	5501	6028	3455	2923	3923	1329	0
1	1164	1450	961	618	1598	1816	2004	1057	1057	1332	482
2	304	385	375	191	197	295	334	279	189	214	245
3	79	73	103	53	34	66	78	68	40	35	44
4	7	19	25	16	7	9	12	24	17	9	7
+gp	6	23	8	9	4	5	5	12	16	10	5
0 TOTAL	5696	4816	3465	5378	7340	8219	5887	4363	5242	2928	783

The figure below (Fig. 5.3.4.1.3.1) show the main XSA results. Both stock abundance and biomass show important oscillation during the data series, although stock biomass has been more constant during the last 15 years. Recruits showed three maximums (around 1984, 1991 and 2005) and minimum values in 1994, 2002 and 2009. Fishing mortality seems quite constant during the last 5 years.

Fig. 5.3.4.1.3.1 Assessment results: stock abundance and biomass, number of recruits, spawning stock biomass and fishing mortalities by year and age for *M. merluccius* in GSA 05.

Tab. 5.3.4.1.3.4 XSA stock parameters summary table.

	RECRU	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 0- 4
	Age 0					
1980	2830	317	113	155	1.3765	1.2038
1981	2294	176	64	76	1.1862	1.116
1982	5176	207	44	49	1.1183	0.7858
1983	8691	359	44	63	1.4195	0.5208
1984	7393	434	93	160	1.7083	0.8431
1985	5540	382	108	162	1.5024	1.123
1986	2867	286	78	126	1.6221	1.1386
1987	3351	211	52	58	1.1236	0.6449
1988	4514	239	55	74	1.3548	0.8824
1989	3528	257	57	81	1.4266	0.6759
1990	3957	282	76	68	0.8921	0.5173
1991	8152	234	110	84	0.7617	0.5654
1992	5083	449	128	189	1.4779	0.9358
1993	4195	340	95	105	1.1116	0.6485
1994	1783	278	103	103	1.0045	0.6442
1995	2458	236	137	61	0.4454	0.4325
1996	2650	259	147	46	0.3108	0.2747
1997	3501	256	134	60	0.4455	0.5139
1998	3269	240	92	92	0.9959	1.0289
1999	3387	192	66	45	0.6859	0.583
2000	4136	232	81	59	0.7246	0.6168
2001	2866	291	128	82	0.6352	0.577
2002	1993	240	121	100	0.8278	1.0335
2003	4491	180	70	48	0.6935	0.8635
2004	5501	233	48	66	1.3696	0.6682
2005	6028	295	75	93	1.2306	0.8081
2006	3455	298	89	111	1.2435	0.8428
2007	2923	257	97	99	1.0205	0.8955
2008	3923	222	75	76	1.0183	0.8518
2009	1329	203	62	75	1.2203	0.8356

5.3.5. Long term prediction

5.3.5.1. Justification

A Yield per Recruit analysis was performed as defined below.

5.3.5.2. Input parameters

Yield per recruit analysis was conducted based on the exploitation pattern resulting from the XSA model and population parameters. Minimum and maximum ages for the analysis were 0 and 5 years, respectively. Stock weight at age and catch weight at age were estimated as mean values on a long term basis (1980-2009). Natural mortality by age was from PROBIOM (Abella *et al*. 1997). Fishing mortalities used came from last year (2009). Reference F was considered to be mean F for ages 0 to 4.

Table 5.3.5.2.1 YpR input parameters.

Age group	Stock weight	Catch weight	Maturity	F	M
0	0.018	0.018	0	0.08	1
1	0.063	0.063	0.05	1.04	0.7
2	0.203	0.203	0.56	1.13	0.5
3	0.44	0.44	0.89	1.07	0.4
4	0.752	0.752	0.98	0.93	0.4
5+	1.352	1.352	1	0.85	0.4

5.3.5.3. Results

The reference fishing mortality (F_{ref}) is displayed in the following Table 5.3.5.3.1, along with the estimated reference points $F_{0.1}$ and F_{max}. Fig 5.3.5.3.1. shows the results of the yield per recruit analysis.

Table 5.3.5.3.1 YpR results. F_{ref} is calculated over ages 0-4.

F0.1	0.22
Fmax	0.37
Fref	0.84

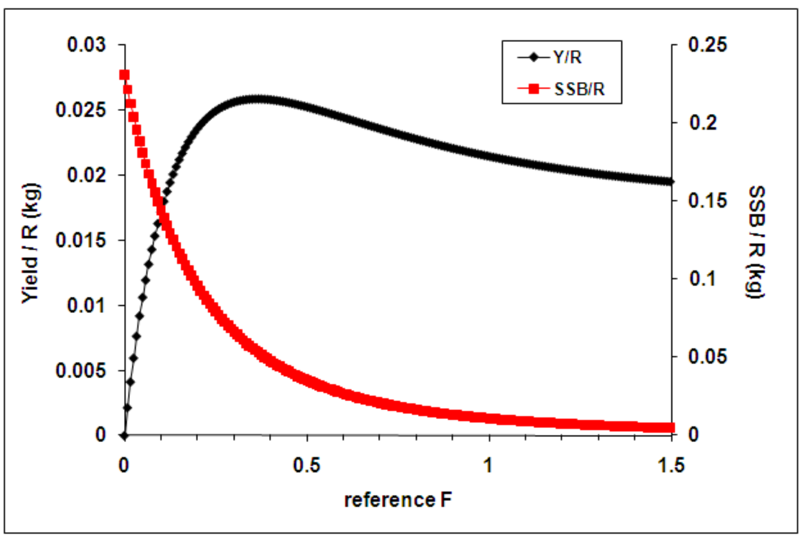


Fig. 5.3.5.3.1 Results of the yield per recruit analysis showing the Y/R and SSB/R with increasing F.

5.3.6. Data quality

Data from Spain was not submitted on time through the Official Data call but only sent by email later on and therefore not accepted. The assessment was carried out with data from the Spanish Data Collection Program.

5.3.7. Scientific advice

5.3.7.1. Short term considerations

5.3.7.1.1. State of the spawning stock size

SSB showed significant oscillations in short term during the entire data series since 1980, with maximum values in the middle of the series (1990s) and with a slight decreasing trend during the most recent years.

5.3.7.1.2. State of recruitment

Although recruitment also showed important oscillations, high values (around 8.5 millions) found in the 1980s and 1990s were not been repeated since then. In the most recent period, there is a maximum (around 6 millions) in 2005, but with an increasing trend since then. Recruitment in 2009 is estimated to be the lowest since 1980.

5.3.7.1.3. State of exploitation

Mean fishing mortality over ages 0 to 4 years showed oscillations during the entire data series, although it has been quite stable during the last 5 years. The vector of fishing mortality over age displays a typical selection curve and shows that the highest fishing exploitation is estimated for 1 and 2-year-old individuals and also that the exploitation of the recruits (age 0) is very low. The current F_{ref} (0.84) is above the Y/R $F_{0.1}$ reference point (0.22), which indicates that hake in GSA 05 is overexploited.

5.4. Stock assessment of hake in GSA 06

5.4.1. Stock identification and biological features

5.4.1.1. Stock Identification

Due to a lack of information about the structure of hake population in the western Mediterranean, this stock was assumed to be confined within the GSA 06 boundaries.

5.4.1.2. Growth

The growth parameters used in the assessment were obtained through DCF official data call and are L_{inf}= 85.0; k = 0.172, t_0= -0.177. These parameters are different from those used the year before, which corresponded to a fast growth of the species. The length-weight relationship parameters are a=0.0032 and b=3.21, also taken from DCF.

5.4.1.3. Maturity

The maturity ogive was obtained through DCF official data for the period 2002- 2004, with size at first maturity (50%, both sexes combined) at 32 cm TL. The maturity status was determined by macroscopic examination of the gonads during the reproductive period (no indication was provided on the months when sampling of the gonads was conducted).

Table 5.4.1.3.1 Maturity ogive of hake in GSA 6.

Age class	0	1	2	3	4	5	6	7
Maturity ratio	0	0	0.14	0.77	0.96	0.99	1	1

5.4.2. Fisheries

5.4.2.1. General description of fisheries

The trawl feet operating in GSA06 in 2009 consisted of 603 trawlers, according to the statistics of the Autonomous Governments of Valence (305 in southern GSA06) and Catalonia (298 in northern GSA06). Trawl hake landings in GSA06 in 2009 were 3,754 tons (compared to 71 tons in GSA05 and 489 tons in GSA01).

Hake (*Merluccius merluccius*) is one of the most important target species for the trawl fisheries carried out by around 647 vessels in the Northern Spain (GSA 06) with an average of 47 TRB, 58 GT and 297 HP. Some of these units (smaller vessels) operate almost exclusively on the continental shelf (targeting at red mullet, octopus, hake and sea breams), others (bigger vessels) operate almost exclusively on the continental slope (targeting decapod crustaceans) and the rest can operate indistinctly on the continental shelf and slope fishing grounds, depending on the season, the weather conditions and also economic factors (e.g. landings price). The percentage of these trawl fleet segments has been estimated around 30%, 40% and 30% of the boats, respectively. In the last years (2002-2009), the annual landings of this species, which are mainly composed by juveniles living on the continental shelf, were around 3,500 tons in the whole GSA.

5.4.2.2. Management regulations applicable in 2009 and 2010

The Spanish Administration acknowledged the poor status of the fishing resources in the Spanish Mediterranean and approved a plan for the conservation of the fishing resources in the Mediterranean, whose implementation is updated on a bi-annual basis (*Orden APA/254/2008, de 31 de enero, por la que se establece un Plan Integral de Gestión para la conservación de los recursos pesqueros en el Mediterráneo; Orden ARM/143/2010, de 25 de enero, por la que se establece un Plan Integral de Gestión para la conservación de los recursos pesqueros en el Mediterráneo*). This regulation, in line with EU regulations, includes the implementation of spatial and temporal closures along the Spanish coast, and limits the daily and weekly fishing effort to 12 hours per day five days a week. The plan affects purse-seining, bottom trawling, surface longlining and artisanal fishing and will end by 31 December 2012. By then, the number of vessels should have been reduced, at least, by 10%.

5.4.2.3. Catches

5.4.2.3.1. Landings

Fig. 5.4.2.3.1.1 shows the trend in reported hake landings taken by trawlers and the annual size distribution of the landings (minimum landing size of hake in the Mediterranean is set to 20 cm TL). The data were reported to SGMED-10-02 through the Data Collection Framework. The annual landings 2002- 2009 oscillated between 3,200 and 3,800 tons and showed a slight increasing trend.

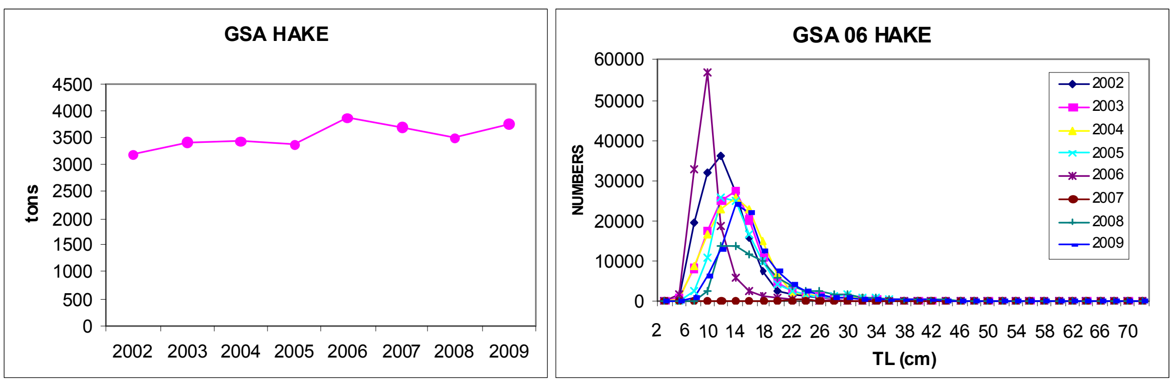


Fig. 5.4.2.3.1.1 Hake annual landings in GSA06, in weight (tons, left) and numbers (right).

Tab. 5.4.2.3.1.1 lists the reported landings, by fishing technique. The landings were reported only for demersal otter trawls. Landings by other fishing techniques (longline, gillnet) are not available. It is worth noting that these fishing gears target the reproductive fraction of the population (trawl landings consisting mostly of very small individuals), and therefore, the spawning stock is practically not taken into account in the input data for the assessment. To exemplify the importance of fishing gears other than bottom trawl in the exploitation of hake, in 2009, along the Catalan Coast (northern GSA06, from the Delta of the Ebre River to the French border) hake annual landings were 2360 tons. Of these, around 20% corresponded to longline and gillnet landings.

Tab. 5.4.2.3.1.1 Annual landings (t) of hake in GSA 06.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	6	ESP	OTB	DEMSP	40D50	3195	3411	3441	3363	3864	3701	3494	3754

5.4.2.3.2. Discards

Reported discards through the DCR data call to SGMED-10-02 amount 80 t in 2005 and 100 t in 2009. No data on the discards size and/or age distributions were submitted.

5.4.2.3.3. Fishing effort

SGMED-10-02 did not receive fishing effort data for GSA 06. STECF in 2007 noted that the trawl fishery off northern Spain (GSA 06) was carried out by around 647 vessels. In 2009 the trawl fleet consisted of 603 trawlers (data from the fishing statistics of the Autonomous Governments of Valence and Catalonia).

5.4.3. Scientific surveys

5.4.3.1. MEDITS

5.4.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 06 the following number of hauls was reported per depth stratum (s. Tab. 5.4.3.1.1.1).

Tab5.4.3.1.1.1. Number of hauls per year and depth stratum in GSA 06, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA06 10-50	7	8	7	8	7	8	9	8	11	9	9	11	12	6	8	6
GSA06 50-100	21	28	27	26	28	30	30	31	36	39	31	32	34	40	43	28
GSA06 100-200	11	19	17	15	13	17	19	20	20	21	17	18	19	24	30	20
GSA06 200-500	10	13	10	12	7	13	12	16	17	18	16	15	18	18	19	12
GSA06 500-800	7	8	9	7	4	9	6	8	7	11	11	8	10	15	14	9

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.4.3.1.2. Geographical distribution patterns

No specific analyses were conducted.

5.4.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 06 was derived from the international survey MEDITS. Figure 5.4.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 06. Data indicate a general increasing trend in both abundance and biomass since 1996 till 2006; during 2007- 2009 values are low, especially regarding abundance.

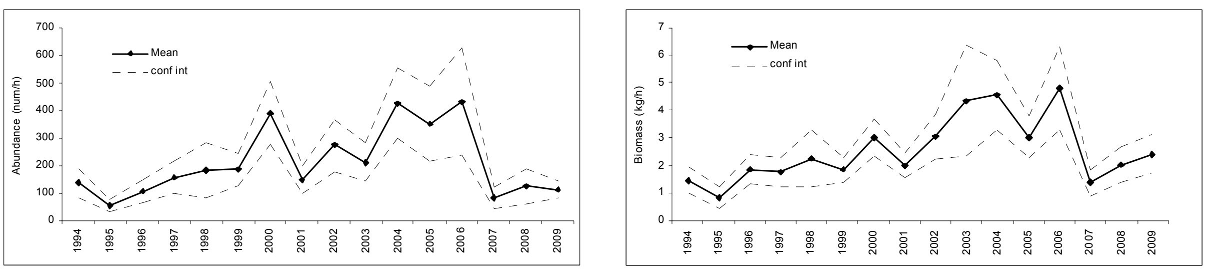


Fig. 5.4.3.1.3.1 Abundance and biomass indices of hake in GSA 06.

5.4.3.1.4. Trends in abundance by length or age

The following Fig. 5.4.3.1.4.1 and 2 display the stratified abundance indices of GSA 06 in 1994-2001 and 2002-2009.

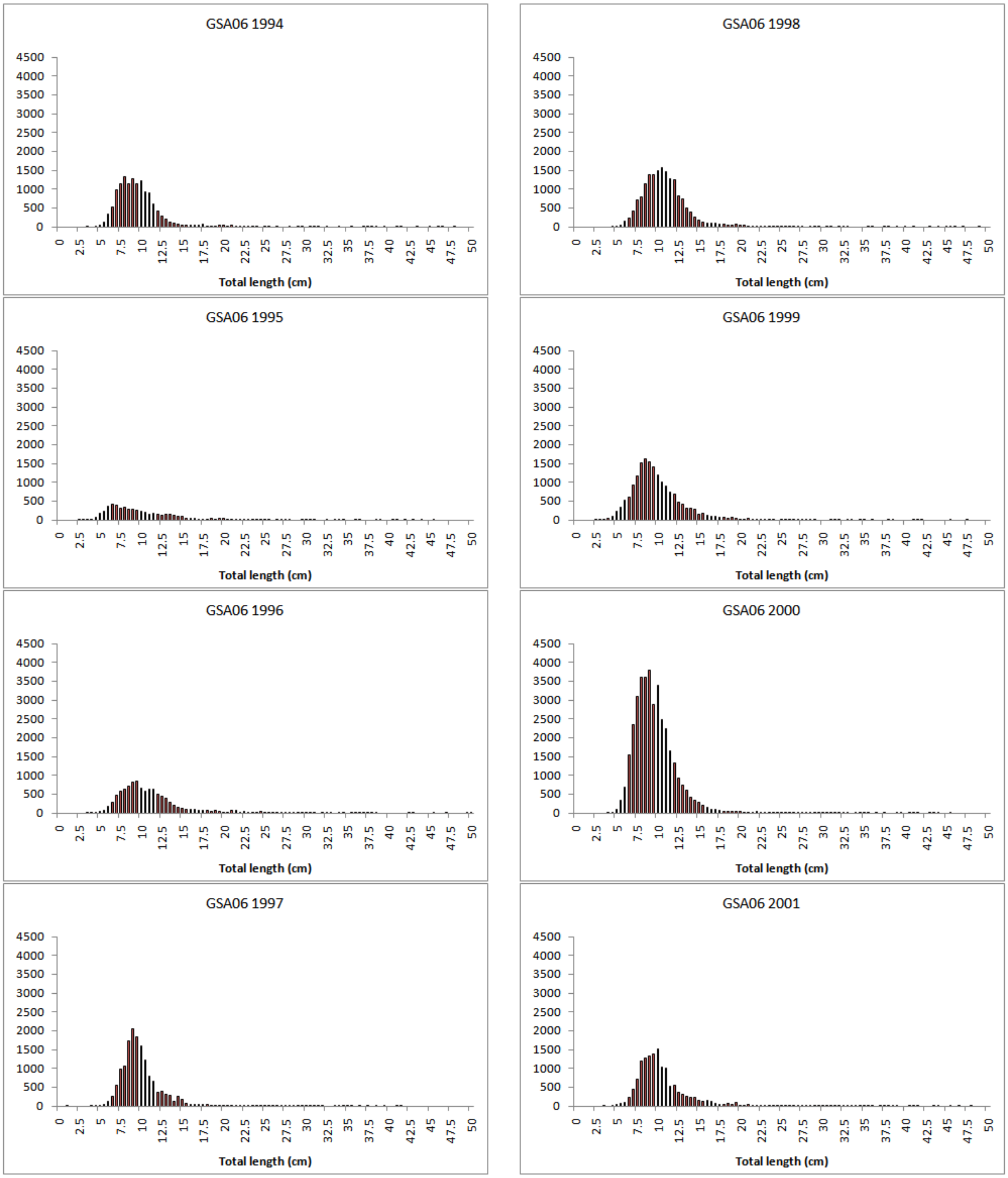


Fig. 5.4.3.1.4.1 Stratified abundance indices by size, 1994-2001.

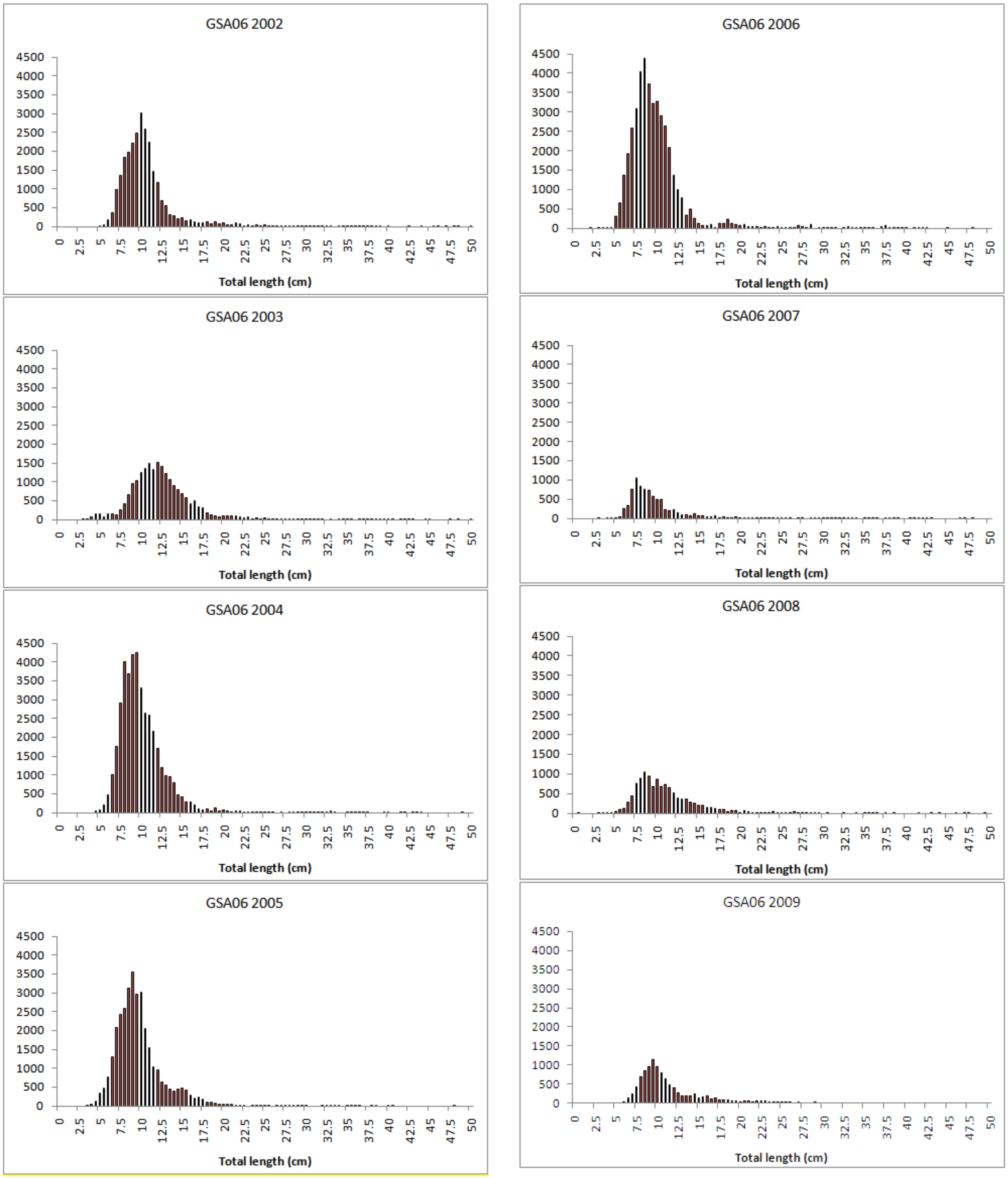


Fig. 5.4.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.4.3.1.5. Trends in growth

No analyses were conducted.

5.4.3.1.6. Trends in maturity

No analyses were conducted.

5.4.4. Assessment of historic stock parameters

During the SGMED-10-02, an assessment on hake from GSA 06 was performed.

5.4.4.1. Method 1: XSA

5.4.4.1.1. Justification

An XSA was performed calibrated with fishery independent survey abundance indices (MEDITS).

5.4.4.1.2. Input parameters

Input data were taken from DCF. Data were available on trawling (no data on long-lining and gill-netting) hence, data basically refer to the juvenile fraction of the population. The growth curve used was that given for hake in GSA05, which is based mainly on juveniles (as landings in GSA06). The growth parameters are: L_{inf}: 85, K=0.172, t_0: -0.177. Numbers by age for 2009 were missing. These were estimated transforming the annual size distribution of the landings to ages using the L2Age4.exe software. The tuning parameters (MEDITS) were calculated by transforming the MEDITS length distributions to ages using L2Age4.exe software.

Table 5.4.4.1.2.1 lists the input parameters to the XSA, i.e. catch at age, weight at age, maturity at age, natural mortality at age and the tuning series at age (MEDITS).

Table 5.4.1.1.2.1. Input parameters to the XSA, i.e. catch at age, weight at age, maturity at age, natural mortality at age and the tuning series at age (MEDITS).

Hake GSA06 Catch at age.

Age	2002	2003	2004	2005	2006	2007	2008	2009
0	173830.76	163215.00	195312.03	116007.14	87394.70	59595.20	36119.57	61789.2
1	8407.65	11050.09	13740.20	11750.26	30864.90	25162.10	25580.87	34072.7
2	1272.56	1242.26	830.78	1072.39	3199.80	3334.30	4997.91	3531.7
3	202.58	275.72	160.89	142.52	707.40	1274.20	809.24	666.3
4	58.78	95.42	53.29	23.91	258.80	304.50	177.13	216.7
5	7.94	37.30	11.00	0.04	106.60	111.80	102.72	79.9
6	0.00	2.44	0.04	0.03	21.20	44.50	42.40	21.3
7+	0.00	0.55	2.15	0.10	15.90	22.00	15.64	0

Hake GSA06 Weight at age in kg.

AGE	2002	2003	2004	2005	2006	2007	2008
0	0.007	0.006	0.006	0.009	0.013	0.013	0.006
1	0.130	0.126	0.119	0.146	0.045	0.048	0.057
2	0.428	0.434	0.432	0.459	0.201	0.211	0.198
3	0.860	0.864	0.865	0.890	0.420	0.427	0.438
4	1.327	1.332	1.336	1.365	0.782	0.753	0.749
5	1.814	1.771	1.814	1.829	1.030	1.109	1.089
6	2.253	2.234	2.253	2.251	1.448	1.438	1.450
7+	2.253	2.253	2.253	2.253	2.253	2.253	2.253

Males and females combined.			
Age class	Maturity ratio	AGE	M
0	0.00	0	1.36
1	0.00	1	0.57
2	0.14	2	0.37
3	0.77	3	0.30
4	0.96	4	0.27
5	0.99	5	0.25
6	1.00	6	0.24
7	1.00	7	0.23
8	1.00	8	0.22
9	1.00	9	0.21
10	1.00	10	0.21

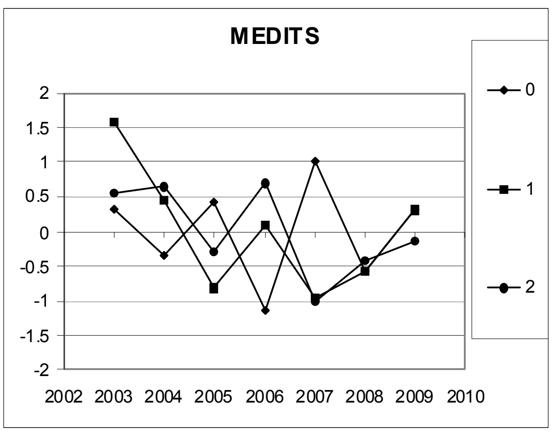
Tuning parameters (MEDITS)

MEDITS TUNNING

AGE	2002	2003	2004	2005	2006	2007	2008	2009
0	24165.70	1524.60	199.80	62.80	17.60	6.40	0.00	0.00
1	4.80	414.40	110.20	70.90	19.60	1.40	2.50	1.80
2	2.90	186.20	142.60	53.50	9.70	7.20	0.00	0.00
3	7.20	70.30	87.60	23.40	1.70	1.30	0.00	0.00
4	1.30	257.50	377.60	139.20	3.10	2.20	4.40	3.40
5	10.00	92.40	61.70	26.10	5.40	0.90	1.40	0.00
6	2.30	130.60	124.90	14.60	14.30	0.00	0.00	3.40
7+	3.40	415.40	178.40	38.70	6.00	2.90	0.00	1.60

5.4.4.1.3. Results including sensitivity analyses

Hake XSA model diagnostics are shown in Fig. 5.4.4.1.3.1 and Table 5.4.4.1.3.1. No numeric blocks or trends in the log catchability residuals are recognizable.



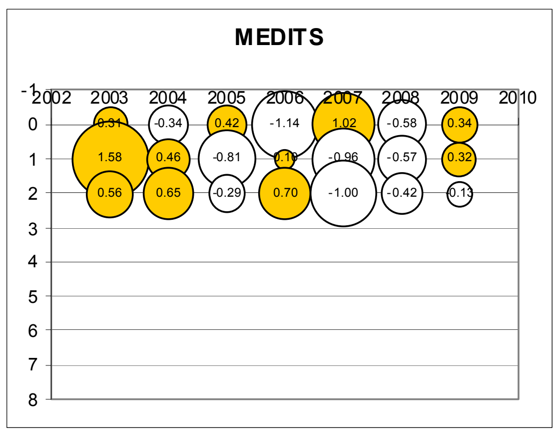


Fig. 5.4.4.1.3.1. Log catchability residual plots (XSA) for single fleets, MEDITS

Table 5.4.4.1.3.1. Hake XSA model diagnosis.

Fishing mortalities

Age	2003	2004	2005	2006	2007	2008	2009
0	1.473	1.527	0.754	0.655	0.497	0.259	0.788
1	1.505	1.357	0.842	1.542	1.203	1.289	1.315
2	0.993	0.547	0.447	0.857	1.008	1.349	0.87
3	1.049	0.368	0.192	0.733	1.406	0.893	0.759
4	2.029	0.647	0.092	0.715	0.964	0.842	0.721
5	6.337	4.368	0.001	0.815	0.879	1.237	1.482
6	2.417	1.481	0.317	0.918	1.112	1.147	1.045

Log catchability residuals

2003	2004	2005	2006	2007	2008	2009
0.31	-0.34	0.42	-1.14	1.02	-0.58	0.34
1.58	0.46	-0.81	0.1	-0.96	-0.57	0.32
0.56	0.65	-0.29	0.7	-1	-0.42	-0.13

Regression weights

2003	2004	2005	2006	2007	2008	2009
0.921	0.954	0.976	0.99	0.997	1	1

Table 5.4.4.1.3.2 Fishing mortality at age as estimated by XSA.

Fishing mortality (F) at age

YEAR		2002	2003	2004	2005	2006	2007	2008	2009	FBAR 2007-2009
AGE										
	0	1.7338	1.4727	1.527	0.7541	0.6554	0.4966	0.2588	0.7876	0.5143
	1	1.2984	1.5045	1.3572	0.842	1.5422	1.203	1.2895	1.3147	1.269
	2	1.1458	0.9934	0.5469	0.4468	0.8569	1.0083	1.3489	0.8702	1.0758
	3	0.8699	1.0489	0.368	0.1919	0.7328	1.4058	0.8933	0.7587	1.0193
	4	0.7943	2.0286	0.6474	0.092	0.7148	0.9641	0.842	0.7213	0.8425
	5	1.1999	6.3366	4.3679	0.0009	0.8147	0.8789	1.2374	1.4818	1.1994
	6	0	2.4173	1.4808	0.3166	0.9183	1.1123	1.1467	1.0446	1.1012
	+gp	0	2.4173	1.4808	0.3166	0.9183	1.1123	1.1467	1.0446	
0 FBAR 0- 2		1.3927	1.3235	1.1437	0.6809	1.0182	0.9026	0.9657	0.9908	
FBAR 2- 4		0.9367	1.357	0.5208	0.2435	0.7682	1.1261	1.028	0.7834	

Table 5.4.4.1.3.3 Stock numbers (thousands) at age as estimated by XSA.

	Stock number at age (start of year)			Numbers*10**-3					
AGE	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	416719	418026	492487	432411	358824	300546	312641	223760	0
1	15378	18890	24603	27454	52212	47820	46946	61944	26127
2	2245	2374	2373	3581	6689	6316	8121	7312	9408
3	405	493	607	949	1582	1961	1592	1456	2116
4	123	126	128	311	580	563	356	483	505
5	13	42	13	51	217	217	164	117	179
6	0	3	0	0	40	75	70	37	21
+gp	0	1	3	0	29	36	25	0	10

Table 5.4.4.1.3.4 Summary of stock parameters as estimated by XSA.

	RECRUITS Age 0	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 0- 2	FBAR 2- 4
2002	416719	6563	596	3195	5.3602	1.0237	1.3927	0.9367
2003	418026	6718	729	3411	4.6803	1.0186	1.3235	1.357
2004	492487	7723	750	3441	4.5858	1.0117	1.1437	0.5208
2005	432411	10753	1362	3363	2.4688	0.9858	0.6809	0.2435
2006	358824	9874	1487	3864	2.5984	1.0051	1.0182	0.7682
2007	300546	9236	1667	3701	2.2209	1.0012	0.9026	1.1261
2008	312641	7758	1407	3494	2.4838	1.0399	0.9657	1.028
2009	223760	8642	1307	3754	2.871	1.1108	0.9908	0.7834
Mean	369427	8408	1163	3528	1.0523	0.8455		

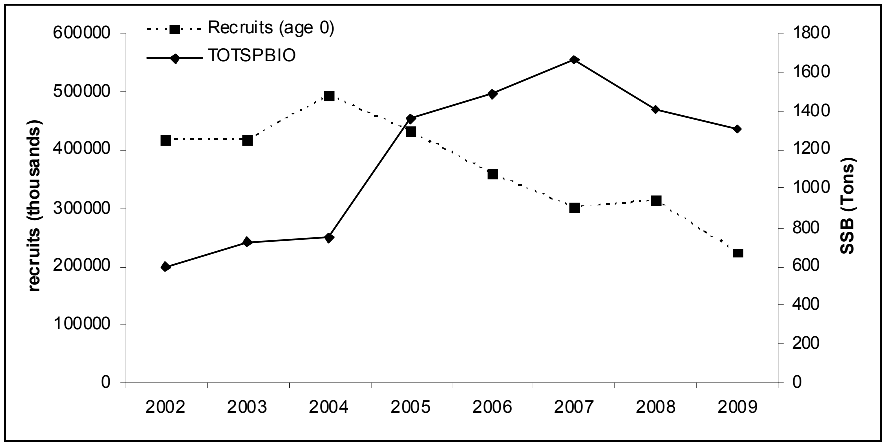


Fig. 5.4.4.1.3.2 Trends in spawning stock SSB and recruits at age 0.

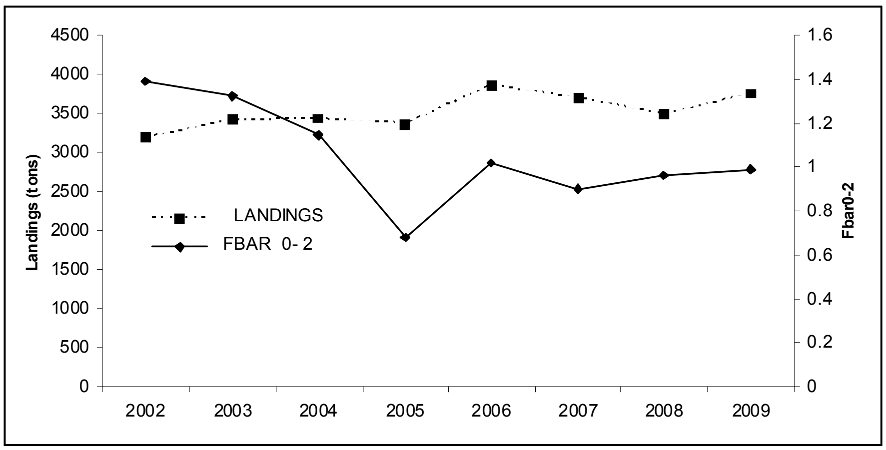


Fig. 5.4.4.1.3.3 Trends in landings and mean fishing mortality over ages 0-2.

Recruitment shows a decreasing trend since 2005, while SSB increased during 2002-2007; in 2008-2009 SSB decreased to values similar to those of 2005 (Fig. 5.4.4.1.3.2). Fishing mortality ($Fbar_{02}$) decreased from 2002 to 2005 (1.4 to 0.7, lowest value), and in the most recent years, 2006-2009, remained fairly constant around 1 (Fig. 5.4.4.1.3.3). The exploitation is concentrated on very young age classes, mainly 0 and 1.

5.4.5. Long term prediction

5.4.5.1. Justification

Y/R was used for the estimation of $F_{0.1}$ and F_{max}.

5.4.5.2. Input parameters

F_{ref} is $Fbar_{02}$ over 2007-2009. All input parameters are listed in Table 5.4.5.2.1 below.

Table 5.4.5.2.1 YpR inputs.

age group	stock weight	catch weight	maturity	F	M
0	0.009	0.009	0	0.788	1.355
1	0.089	0.089	0	1.315	0.57
2	0.318	0.318	0.14	0.87	0.37
3	0.649	0.649	0.77	0.759	0.303
4	1.044	1.044	0.96	0.721	0.27
5	1.444	1.444	0.99	1.482	0.25
6	1.834	1.834	1	1.045	0.237
7	1.007	1.007	1	1.045	0.227
8	1.652	1.652	1	1.045	0.22
9	2.536	2.536	1	1.045	0.214
10	3.701	3.701	1	1.045	0.21

5.4.5.3. Results

Results are shown in Fig. 5.4.5.3.1: $F_{ref} = 0.95$; $F_{0.1} = 0.14$; $F_{max} = 0.21$

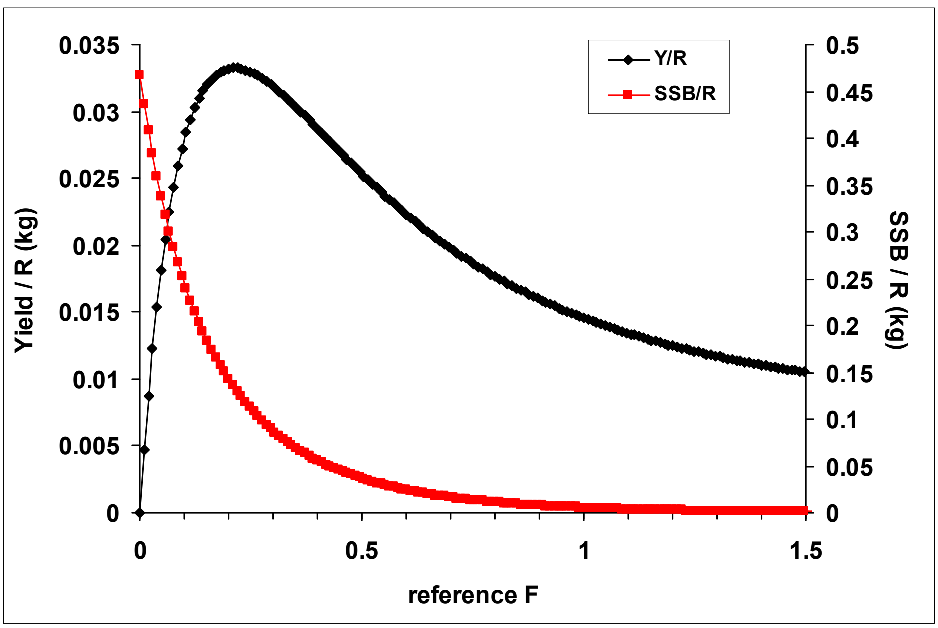


Fig. 5.4.5.3.1 Results of the Y/R analysis, Y/R and SSB/R.

$Fbar_{02}$ was chosen because classes 0-2 are the most abundant in trawl landings. This is also the age range used in previous SGMED assessments. Y/R was also run for $Fbar_{13}$, since class 1 is the younger class fully recruited to the fishing gear. Results from both analyses are very similar ($F_{ref} = Fbar_{13}$ over 2007-2009= 1.12; $F_{0.1} = 0.17$; $F_{max} = 0.25$).

5.4.6. Data quality and availability

Data format and, length class interval: Until 2008 the length class interval was 2 cm, but in the last data call the class interval was given at 1cm. SGMED recommends to maintain 2 cm interval for hake length classes.

Data format and, units: The unit of 2007 data on catch at length (numbers) is different from that used the other years.

Inconsistencies between files: The numbers of the annual landings and those of the annual landings by size are not coincidental in four (2002-2005) out of eight years of sampling (2002-2009). Largest inconsistency was observed for 2004 (40% of difference in numbers between the file of landings and the file of landings by size).

Data not available: No data of fishing effort were submitted for the period requested (2002-2009). No data available on the discards sizes or age distributions. Landings by other fishing techniques (longline, gillnet) than trawl are not available. Those are very important for the assessment because they exploit the adult portion of the stock. SGMED underlines again that all métiers targeting hake are needed to be sampled for a correct assessment of hake.

Growth parameters: Growth parameters given for 2005-2007 and for 2008-2009 are the same and t_0 are wrong. These growth parameters are also the same given for GSA05 (L_{inf}= 85, k= 0.172, t_0= -0.177). SGMED notes that the growth parameters given for the period 2002-2004 are very different from those given for the other periods (L_{inf}= 120, k= 0.124, t_0= -0.505) although in all cases the methodology used is otoliths reading.

Discards: Hake discards (weight, 2005, 2007 and 2009) is officially attributed to "surrounding nets".

MEDITS: Abundance and biomass indexes in 1998 should be checked, values are very low.

5.4.7.Scientific advice

5.4.7.1. Short term considerations

5.4.7.1.1. State of the spawning stock size

During 2002-2007 SSB displayed an increasing trend, while in the last two years, 2008-2009 SSB decreased.

5.4.7.1.2. State of recruitment

Recruitment shows a decreasing trend since 2005.

5.4.7.1.3. State of exploitation

By comparing $F_{0.1}$ and F_{max} against F_{ref}, taking as reference $Fbar_{02}$ over 2007-2009 and $Fbar_{13}$ over 2007-2009, it can be concluded that the resource is heavily over-exploited.

The continued low abundance of adult fish in the surveyed population and landings indicate a very high exploitation pattern far in excess of those achieving high yields and low risk of fisheries collapse. It is worth noting that SGMED proposed F≤ 0.2 as a management target (SGMED 09-02 report), based on a revised stock assessment considering the fast growth hypothesis. Other management targets proposed by SGMED were B_{pa}(spawning stock) ≥ 4,000 t and B_{lim}(spawning stock) ≥ 2,200 t. Current SSB is well below these targets (estimated SSB in 2009= 1,117 t).

SGMED stresses also that results regarding the increasing SSB since 2005 may be misleading because hake is exploited by fishing gears other than bottom trawl (longline and gillnet), which target the reproductive fraction of the population and the landings and biological data corresponding to these fishing gears have not been taken into account in the analysis.

Results of this assessment show lower values of F than those presented in the previous assessment of hake in GSA06 (SGMED 09-02 report), where it was shown that F fluctuated around 1.6 ($Fbar_{02}$). The different input data used may explain the differences in the results of the assessments conducted during SGMED-09-02 and SGMED-10-02. The data series used in this assessment is much shorter (2002-2009) than that used in the previous assessment (1995-2008). In any case, results are coincidental in that hake is heavily over-exploited.

5.5. Stock assessment of hake in GSA 07

5.5.1. Stock identification and biological features

5.5.1.1. Stock Identification

Hake (*Merluccius merluccius*) of the Gulf of Lions (GSA 7) is a shared stock exploited by both Spanish and French fishing fleets (trawlers, longliners and gillnetters).

5.5.1.2. Growth

Growth of European Hake (*Merluccius merluccius*) in the Gulf of Lions was recently estimated from tagging experiments developed by IFREMER in the area (Mellon-Duval et al., 2010). The parameters used during the SGMED-10-02 are the following :

Table 5.5.1.2.1 Growth parameters of hake in the Gulf of Lions.

	Males	Females
Linf	72.8	100.7
K	0.233	0.236
To	no	no

The new parameters obtained are at the moment not linked to a new reading of otoliths. For that reason the data sent for the data call are in length (no data in age) and converted to age using the L2Age or VIT program.

5.5.1.3. Maturity

The reproduction is all the year with 2 maxima (in automn and beginning of the spring). The first maturity at length is around 28 cm for males and around 38 cm for females.

Table 5.5.1.3.1 Maturity at age (Aldebert & Recasens, 1996).

Age	0	1	2	3	4	5	6	7	8+
M	0	0	0.45	0.98	1	1	1	1	1

5.5.2. Fisheries

5.5.2.1. General description of fisheries

Hake *(Merluccius merluccius*) is one of the most important demersal target species of the commercial fisheries in the Gulf of Lions (GFCM-GSA07). In this area, hake is exploited by French trawlers, French gillnetters, Spanish trawlers and Spanish long-liners. Around 230 boats are involved in this fishery and, according to official statistics, total annual landings for the period 1998-2009 have oscillated around a mean value of 2160 t (2260 t in 2009). The fishing capacity of the GSA 07 has shown in these last 10 years a progressive decrease considering the French trawlers. The number of these trawlers decreased of about 30% on the period.

Most fleets and catches correspond to French trawlers (49 and 70%, respectively). Trawlers catches range between 3 and 92 cm total length (TL), with an average size of 20 cm TL, followed by French gillnetters (~32 and 15% respectively, ranging 13-86 cm TL and average size 39 cm TL), Spanish trawlers (~12 and

8%, respectively, ranging 5-87 cm TL, and average size 25 cm TL), and Spanish long-liners (~7 and 7%, respectively, ranging 23-96 cm TL and average size 54 cm TL). Hake trawlers fishery exploits a highly diversified species assemblage: Striped mullet (*Mullus barbatus*), Red mullet (*Mullus surmuletus*), Angler (*Lophius piscatorius*), Black-bellied angler (*Lophius budegassa*), European conger (*Conger conger*), Poor-cod (*Trisopterus minutus capelanus*), Fourspotted megrim (*Lepidorhombus boscii*), Soles (*Solea spp.*), horned octopus (*Eledone cirrhosa*), squids (*Illex coindetii*), Gilthead seabream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), Seabreams (*Pagellus spp.*), Blue whiting (*Micromesistius poutassou*), Tub gurnard (*Chelidonichtys lucerna*) are among the most important accompagning species.

5.5.2.2. Management regulations applicable in 2009 and 2010

French Trawlers :

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 CV: not observed
- Cod-end mesh size(bottom trawl: square 40 mm; pelagic trawl: diamond 20 mm): not fully observed
- Fishing forbidden within 3 miles (France): not fully observed
- Time at sea: fully observed

French gillnetters :

- Fishing license: fully observed
- Maximum length of net: not fully observed

Spanish trawlers :

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 CV: not observed
- Mesh size in the codend (40 mm diamond): fully observed
- Fishing forbidden <50 m depth: fully observed
- Time at sea: fully observed

Spanish longliners :

- Fishing license: fully observed
- Number of hook per boat: not fully observed

5.5.2.3. Catches

5.5.2.3.1. Landings

SGMED-10-02 received French landings data for GSA 07 which are listed in Tab. 5.5.2.3.1.1. Spanish data for GSA 07 were informally submitted by email as response to the official DCF data call (Table 5.5.2.3.1.1).

Table 5.5.2.3.1.1. French and Spanish landings (t) by year and major gear types, 2002-2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	7	FRA	GNS	DEMSP	50D100	177	248	99	255	299	168	111	287
HKE	7	FRA	LLS	DEMSP	NA	5							
HKE	7	FRA	OTB	DEMSP	40D50	2163	2029	1018	995	1011	1277	1898	1633
HKE	7	SP	OTB			231	206	101	125	116	107	192	258
HKE	7	SP	LLS			146	112	78	101	170	143	97	83
Sum						2722	2595	1296	1476	1596	1695	2298	2261

Total catches fluctuated around a mean value of 2,100 t during the study period. The higher values observed appear to be linked with periods of high recruitment.

5.5.2.3.2. Discards

No significant discards for this species in 2009 were reported (8 t from the French small pelagic fisheries, landings of French trawlers are in 2009 around 1,633 t).

5.5.2.3.3. Fishing effort

About 230 boats from France and Spain are engaged in the fishery. The trends in fishing effort by year and major gear type are listed in Tab. 5.5.2.3.3.1 in terms of kW·days. French trawlers (OTB) fishing effort decreased sharply during the period, from 12,970,505 to 5,277,458 kW*days. No Spanish effort data for GSA 07 was provided. No French data for GSA 07, in 2002 and 2009.

Tab. 5.5.2.3.3.1 Trends in fishing effort by year and major gear type.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2002	2003	2004	2005	2006	2007	2008	2009
7	FRA	DRB	MOL	NA	VL0012		701658	498937	1446390	1474302	838511	503036	
7	FRA	FPO	DEMSP	NA	VL0012		543235	362280	332514	1039964	803688	384117	
7	FRA	FYK	CATSP	NA	VL0012		351526	767686	614369	307896	356394	331939	
7	FRA	FYK	DEMSP	NA	VL0012		88164	150748	19209	75212	82356	26460	
7	FRA	GNS	DEMSP	50D100	VL0012		2753363	2884572	4157772	4458473	4305982	3817311	
7	FRA	GNS	DEMSP	50D100	VL1224		93079	336578	116145	121607	437575	268688	
7	FRA	GNS	SLPF	50D100	VL0012		376669	418691	404283	300454	344254	104138	
7	FRA	GNS	SLPF	50D100	VL1224		519612	450742	345686	7500	114572	12854	
7	FRA	GTR	DEMSP	50D100	VL0012		2110894	2529666	3181853	5210760	4128701	3304533	
7	FRA	GTR	DEMSP	50D100	VL1224		270930	204708	153364	446660	532537	215307	
7	FRA	LA	SLPF	NA	VL0012		671916		131612	170907	144068	128347	
7	FRA	LLS	DEMSP	NA	VL0012		919296	662464	634850	1014367	795610	806093	
7	FRA	OTB	DEMSP	40D50	VL0012		58108	66325	120333		92442	66363	
7	FRA	OTB	DEMSP	40D50	VL1224		6565212	4622815	3502636	3567015	2964713	2876130	
7	FRA	OTB	DEMSP	40D50	VL2440		6347185	3761303	2247875	2652169	2881519	2334965	
7	FRA	OTM	SPF	20D40	VL1224		3766550	1330992	1864890	2193060	1144433	931468	
7	FRA	SB-SV	DEMSP	NA	VL0012		272065	145083	60475	364747	291432	304153	

5.5.3. Scientific surveys

5.5.3.1. Medits

5.5.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 07 the following number of hauls was reported per depth stratum (s. Tab. 5.5.3.1.1.1).

Tab. 5.5.3.1.1.1. Number of hauls per year and depth stratum in GSA 07, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA07_010-050	12	12	12	14	12	12	12	12	12	13	12	12	12	14	11	11
GSA07_050-100	32	32	32	35	39	32	32	32	31	38	31	30	33	31	24	29
GSA07_100-200	10	9	9	9	9	9	10	9	9	10	13	11	10	10	7	10
GSA07_200-500	6	6	5	5	5	5	5	6	4	5	5	5	5	5	4	5
GSA07_500-800	8	7	4	5	4	4	6	5	4	5	5	5	5	5	5	5

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

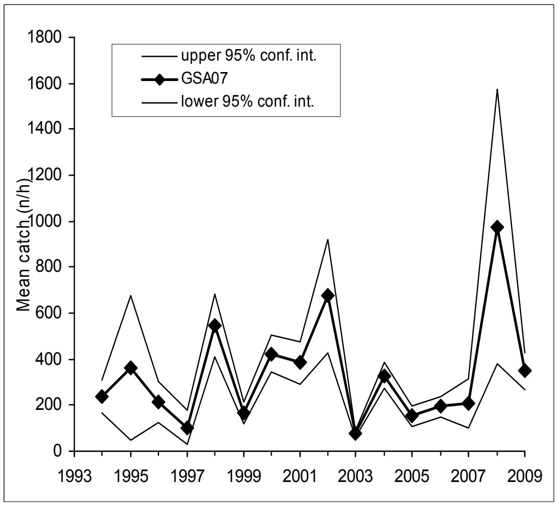
5.5.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.5.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 07 was derived from the international survey MEDITS. Figure 5.5.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 07.

The estimated abundance and biomass indices do not reveal any significant trends except an increase in 2008 likely due to the appearance of a large year class in that year.



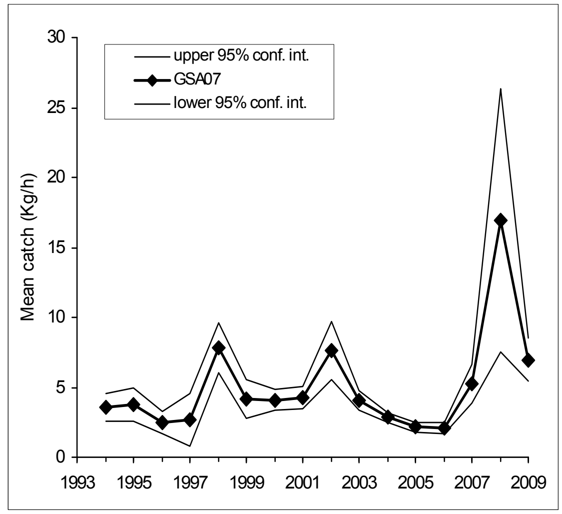


Fig. 5.5.3.1.3.1 Abundance and biomass indices of hake in GSA 07.

5.5.3.1.4. Trends in abundance by length or age

The following Fig. 5.5.3.1.4.1 and 2 display the stratified abundance indices of GSA 07 in 1994-2001 and 2002-2009.

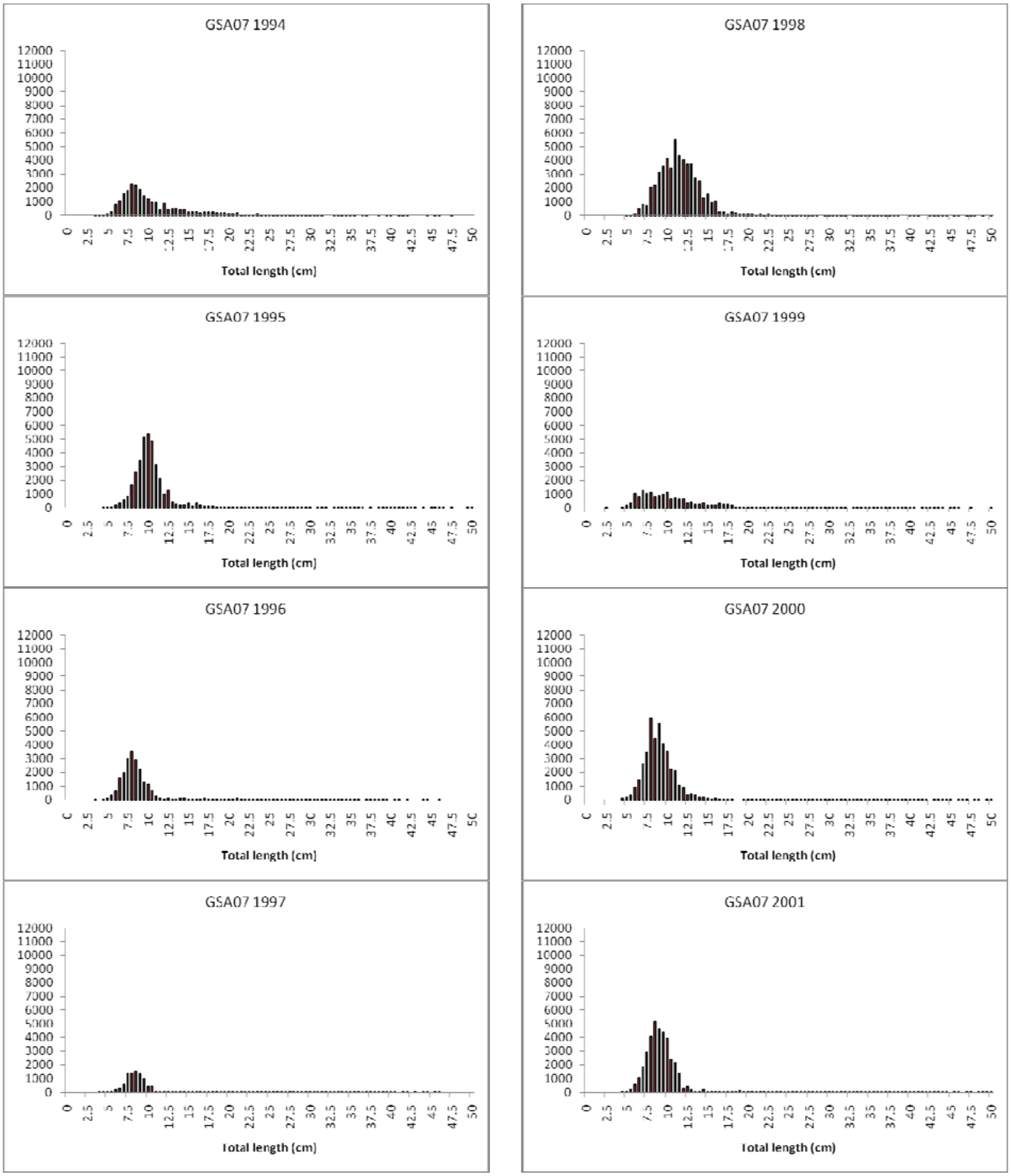


Fig. 5.5.3.1.4.1 Stratified abundance indices by size, 1994-2001.

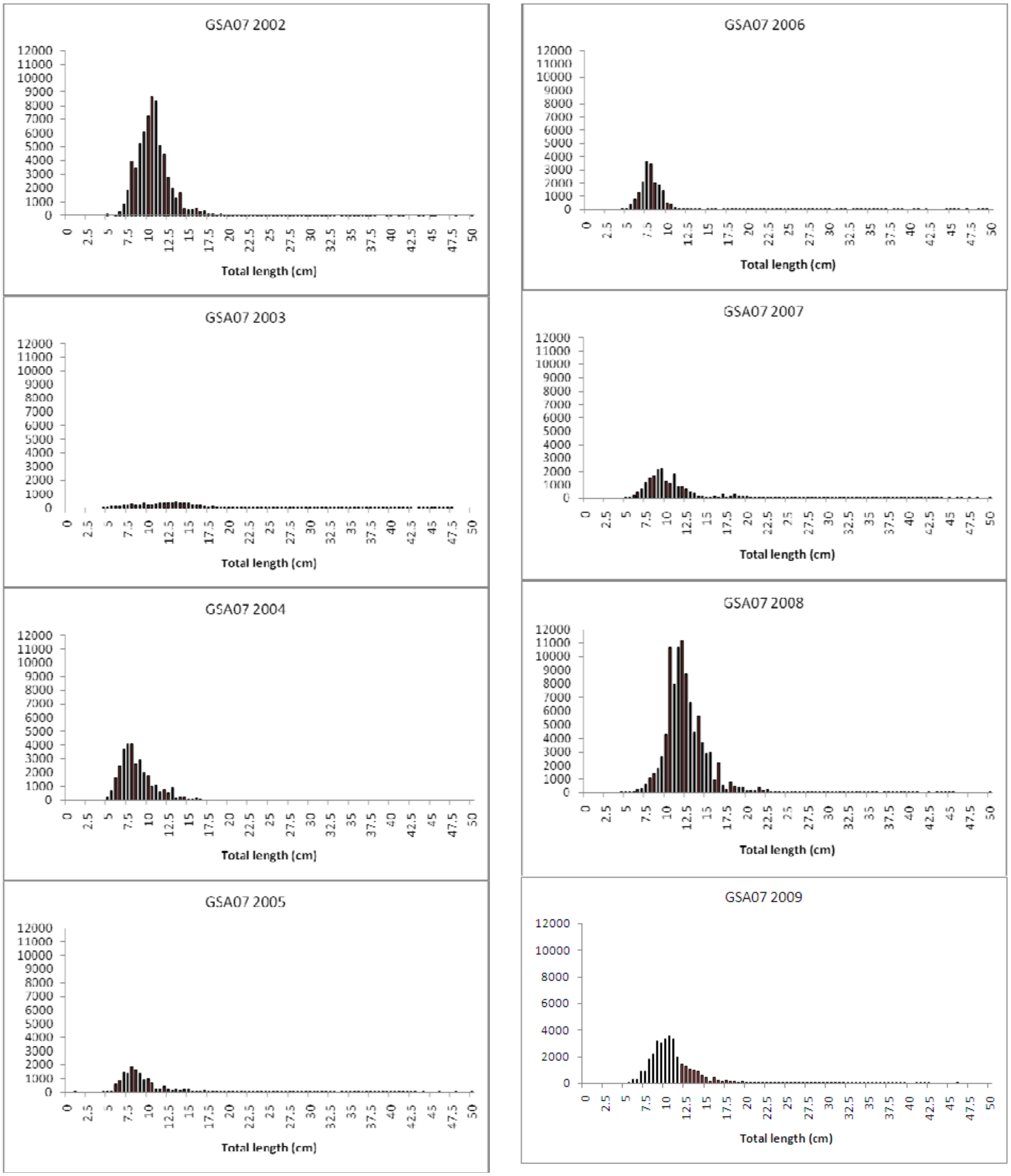


Fig. 5.5.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.5.3.1.5. *Trends in growth*

No analyses were conducted during SGMED-10-02.

5.5.3.1.6. *Trends in maturity*

No analyses were conducted during SGMED-10-02.

5.5.4. Assessment of historic stock parameters

During the SGMED-10-02, an assessment on hake from GSA 07 was performed.

5.5.4.1. Method 1: XSA

5.5.4.1.1. Justification

Hake of GSA 07 was assessed with XSA (Lowestoft VPA V3.2 Darby & Flatman, 1994) tuned with MEDITS indices for 1998-2009 time series. SGMED-10-02 recommended to perform XSA using only MEDITS indices for the tuning because of the no-standardization of the other indices (French trawler, Spanish trawlers and Spanish longliners in kg/day).

5.5.4.1.2. Input data

Total landings (all gears) fluctuated around a value of 2,100 t between 1998-2009 (Figure 5.5.4.1.2.1). High values are linked to exceptional high recruitments. The proportion of each of the four fleets (French and Spanish trawlers, French gillnetters, Spanish longliners) in total landings and in total number of boats are represented in the Figure 5.5.4.1.2.2.

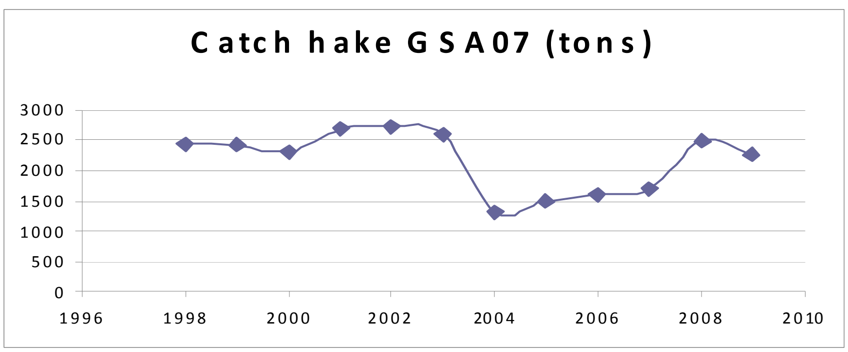


Fig. 5.5.4.1.2.1 Total landings of hake (t) in GSA 07.

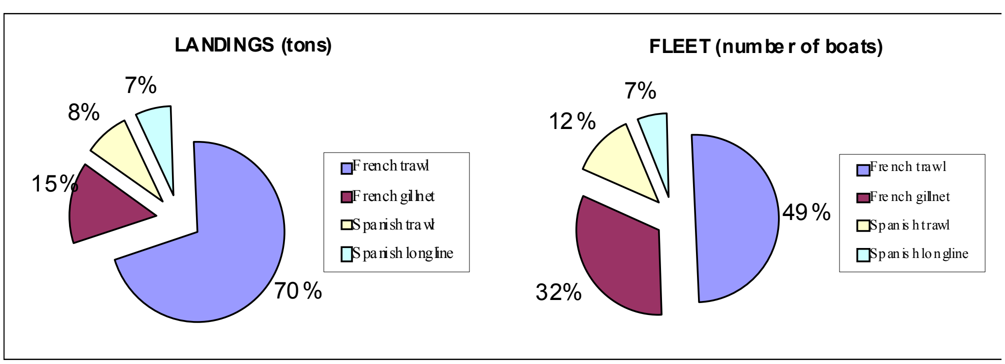


Fig. 5.5.4.1.2.2 Proportion of each gear considering landings and fleets.

Data used were derived from landings by length (Figure 5.5.4.1.2.3) and were converted from length to age using L2age program (Figure 5.5.4.1.2.4). MEDITS indices are shown in Figure 5.5.4.1.2.5.

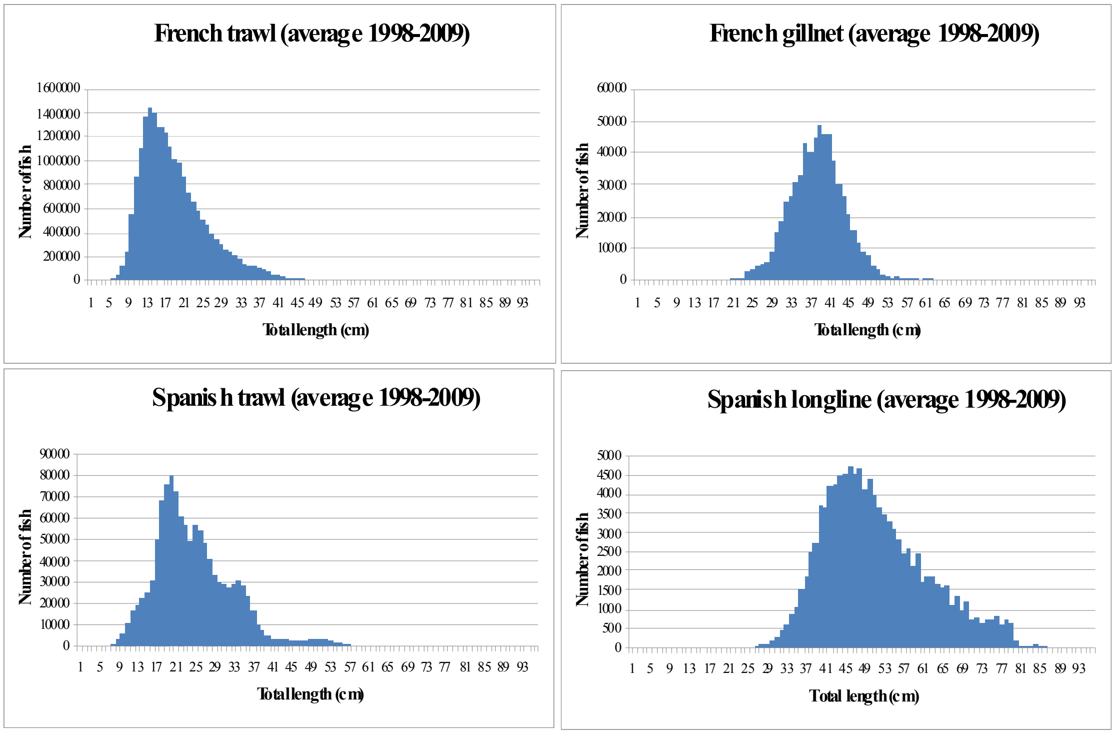


Fig. 5.5.4.1.2.3 Demography of the landings in length for the 4 gears involved in the hake fishery of GSA 07 (mean 1998-2009).

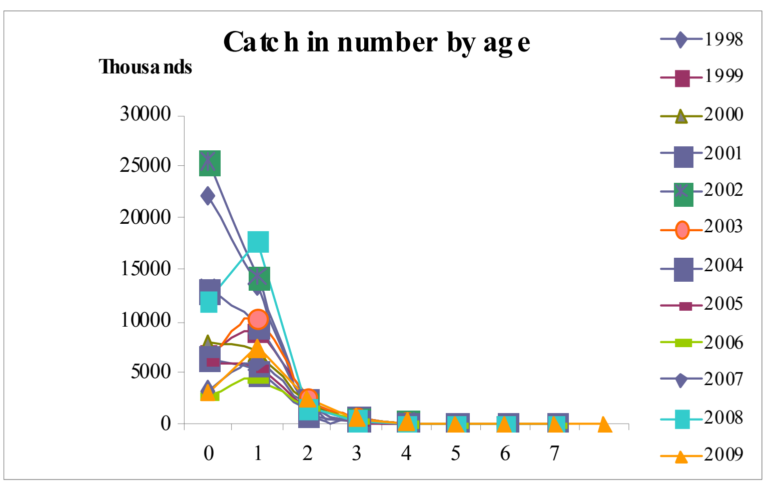


Fig. 5.5.4.1.2.4 Total catch (number/age) of the hake of GSA 07.

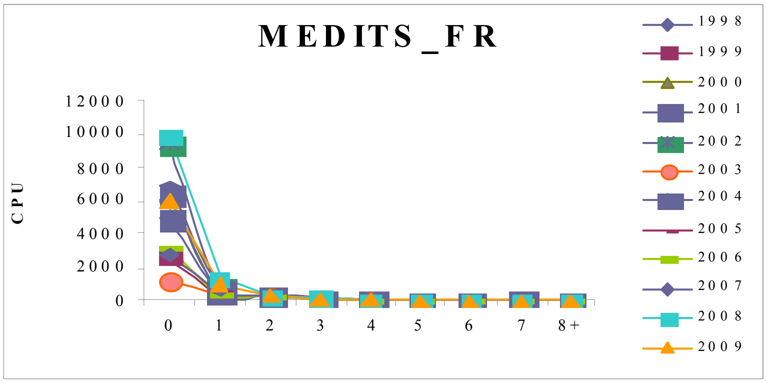


Fig. 5.5.4.1.2.5 Tuning fleet : MEDITS indices (n/km^2).

Biological parameters used are described in the Tables 5.5.4.1.2.1-3 below.

Table 5.5.4.1.2.1 Growth and length-weight (L-W) parameters.

(Mellon et al, 2009)		Males	Females	Both
	Linf (cm, t	72.8	100.7	
	K	0.233	0.236	
	T0	No	No	
L*W				
(Aldebert & Recasens, 1996)	a			0.0069
	b			3.03
Length at maturity				
(Aldebert & Recasens, 1996)		28	40	

Table 5.5.4.1.2.2 Maturity ogive ((Aldebert & Recasens, 1996).

Age	0	1	2	3	4	5	6	7	8+
M	0	0	0.45	0.98	1	1	1	1	1

Table 5.5.4.1.2.3. Natural mortality (ProBiom Abella et al., 1997).

Age	0	1	2	3	4	5	6	7	8+
M	0.68	0.47	0.3	0.22	0.19	0.17	0.16	0.15	0.14

Table 5.5.4.1.2.4 Catch at age (thousands), 1998-2009.

Gulf of Lions	Hake	Catch in Numbers	(thousands)					
1	2							
1998	2009							
0	8							
1								
22148.1	13348	1458.6	429.9	119.3	26.2	10.1	4.6	3.2
6821.9	8961.9	2557.7	564.3	134.6	28.4	9.1	3.8	1.8
7843	6895.6	2023.9	603	175.6	47.9	22.2	6	4.4
13107.4	9705.1	2604.4	644.3	131	39.8	17.3	2.9	2.1
25532.6	14444	2037.1	411.7	86.3	37.4	11.3	3.7	2.6
6292.6	10247.2	2662.3	628.3	87.5	29.7	7.8	7.2	6.7
6507	5255.7	1269.6	314.5	60.1	11.2	4.8	1.8	1
6118.6	5604.7	1519.1	360.9	89.5	14.5	4.5	1.3	0.9
2865.5	4302.1	1534.2	471.9	153.3	31.4	8.4	3	1.7
3287.3	6036.8	1757.8	417.9	109	30.3	12.7	3.5	1.7
12022.8	17832	1528.8	284.1	56.4	17.1	6.4	2.2	1.4
3037.8	7464.9	2552.4	709.5	88	12.8	7.8	1.3	1.3

Table 5.5.4.1.2.5 Tuning fleet (MEDITS). Catch at age, 1998-2009.

HakeGFL 1998-2009		TUNE DATA							
101									
MEDITS-SURVEY									
19 982 009									
1 1 0.25 0.5									
0 5									
1	6904.9	939.3	278.6	120.3	55	18.7	4	0.9	0.1
1	2749.6	607.2	287.5	118.8	31.6	11.2	8.4	0	0
1	6420.2	530.7	284.5	124.4	66.8	27.4	3	1.2	0
1	6511.5	509.7	293.3	102	65	20.4	19	44	6
1	9509.5	815.1	267.1	126.1	23.6	24	15.4	0.9	0
1	1193.6	498.6	282.9	100.2	51.3	5	1.2	1.2	0
1	4938.8	618.8	233	187.9	33.1	9.9	24.2	2.8	0
1	2418.4	443.2	209.3	78.8	21.1	16.1	0	0	0
1	3215	399.7	232.6	54	38.4	0	0	0	0
1	2753.3	631.9	273.2	143.4	55.4	24.2	28	12.1	11.4
1	9839.4	1379.9	223.9	130.1	33.3	13.9	2.4	2.5	0.5
1	6016.5	934.1	290	102.5	42.5	0	8.1	0	0.2

5.5.4.1.3. Results

A separable VPA was run using Fterminal= 0.722. Reference age for unit selection: 1, Terminal S: 0.7. We obtained a vector of F from 2009 (Table 5.5.4.1.3.1).

Table 5.5.4.1.3.1 Vector of fishing mortality obtained from a seperable VPA.

Age	0	1	2	3	4	5	6	7	8+
F	0.19	0.72	0.68	0.7	0.64	0.46	0.54	0.51	0.51

The settings of XSA are defined in the Table 5.5.4.1.3.2.

Table 5.5.4.1.3.2 XSA settings.

Lowestoft VPA Version 3.1

4/06/2010 9:25

Extended Survivors Analysis

Gulf of Lions Hake Stock (1998-2009)

CPUE data from file HakeTUN.dat

Catch data for 12 years. 1998 to 2009. Ages 0 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
MEDITS-SUF	1998	2009	0	5	0.25	0.5

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 3 years or the 2 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2.500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning converged after 124 iterations

1

Regression weights

Regression weights	1	1	1	1	1	1	1	1	1	1

The residual plot of the Log catchability per age and year of the MEDITS indices of the model are shown in the Figure 5.5.4.1.3.1. These results did not show any trend for the ages 0-5 selected for tuning the VPA. The main results of XSA are shown in the Figure 5.5.4.1.3.2.

Since 2004 fishing mortalities were estimated to range at a lower level as compared to previous period. Total stock biomass recently increased and SSB does not show a particular trend. Since 1998, 3 recruitments appear to be above average (1998, 2002 and 2007-2008).

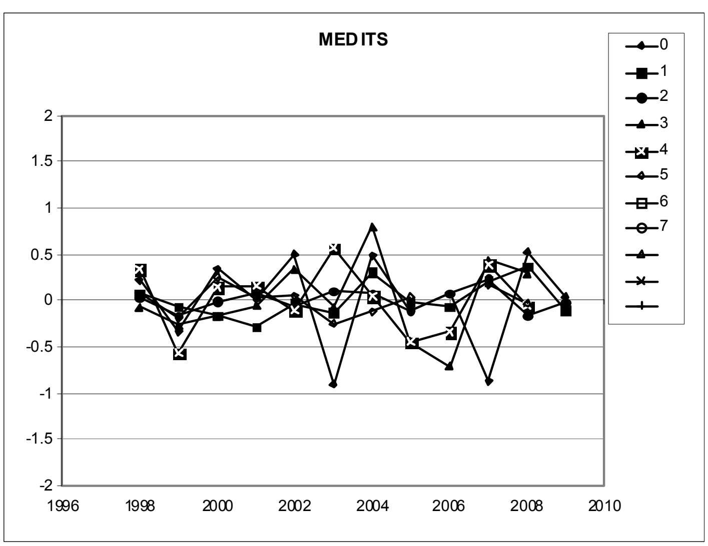


Fig. 5.5.4.1.3.1. Log catchability residuals.

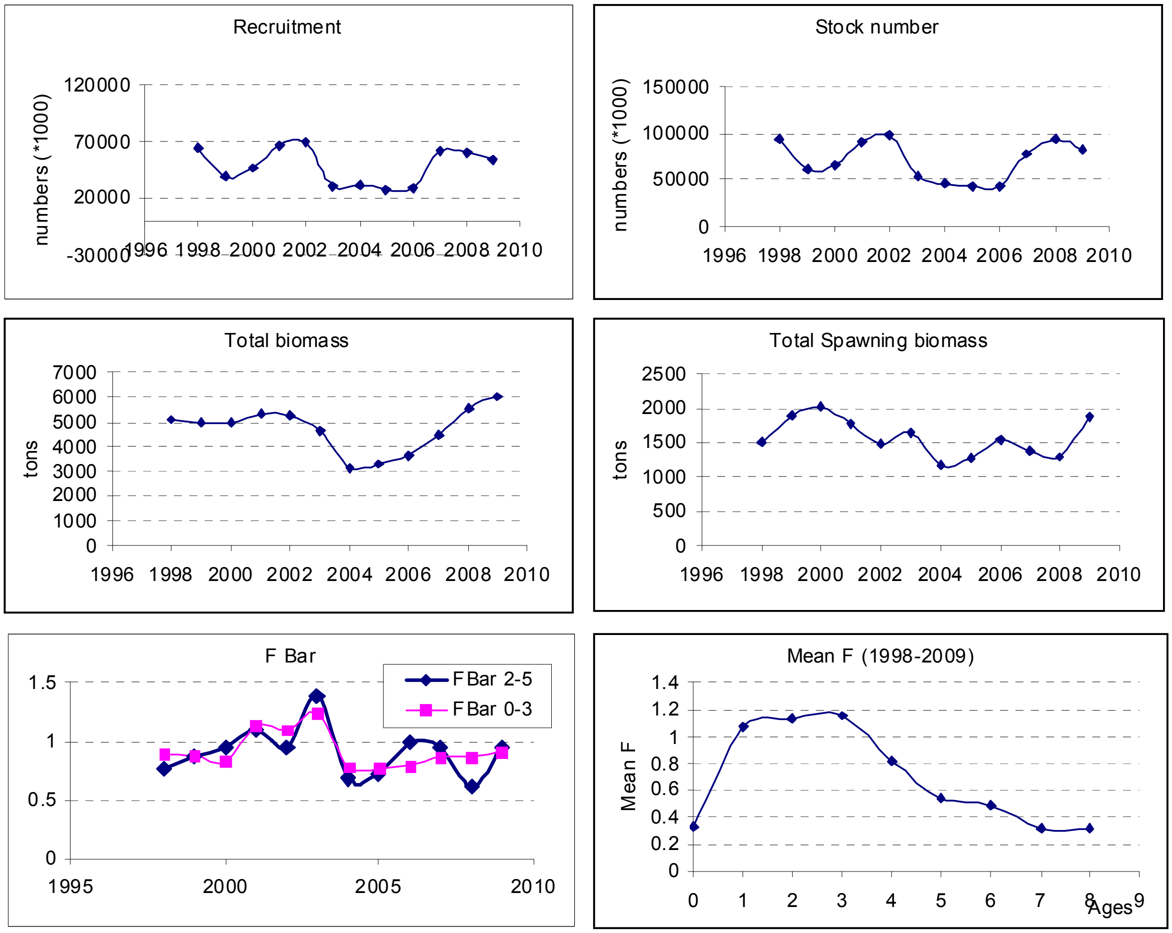


Fig. 5.5.4.1.3.2 The main results of XSA.

Table 5.5.4.1.3.3 XSA estimated fishing mortalities at age.

Table 8 Fishing mortality (F) at age

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE												
0	0.6548	0.2808	0.2704	0.3233	0.7285	0.3378	0.3414	0.3617	0.1505	0.0775	0.3273	0.0811
1	1.2324	1.0936	0.8731	1.1486	1.3765	1.4464	0.9076	0.9754	0.7863	0.9367	1.4991	0.5574
2	0.8037	1.1525	1.0753	1.487	1.0917	1.6201	0.8949	0.9888	1.0927	1.2646	0.8615	1.3149
3	0.8662	0.9651	1.0858	1.5953	1.2106	1.5689	0.9703	0.7624	1.1397	1.205	0.761	1.7294
4	0.9564	0.7541	0.9695	0.7405	1.0389	0.9532	0.5912	0.8497	0.9068	0.9232	0.4896	0.5685
5	0.4315	0.61	0.6531	0.5872	0.47	1.3961	0.2801	0.2651	0.8264	0.4298	0.3355	0.1883
6	0.587	0.2498	1.4906	0.4985	0.3113	0.1597	0.866	0.1663	0.2325	0.9492	0.1436	0.2414
7	0.5122	0.4321	0.2465	0.7437	0.176	0.3171	0.0478	0.572	0.1518	0.1362	0.3861	0.0373
+gp	0.5122	0.4321	0.2465	0.7437	0.176	0.3171	0.0478	0.572	0.1518	0.1362	0.3861	0.0373
0 FBAR 2- 5	0.7644	0.8704	0.9459	1.1025	0.9528	1.3846	0.6841	0.7165	0.9914	0.9557	0.6119	0.9503
Fbar 0-3	0.889275	0.873	0.82615	1.13855	1.101825	1.2433	0.77855	0.772075	0.7923	0.87095	0.862225	0.9207

Table 5.5.4.1.3.4 XSA estimated stock numbers at age.

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	AGE													
	0	64765	39148	46502	66657	69335	30839	31605	28325	28813	61944	60512	54758	0
	1	23833	17047	14978	17976	24440	16953	11145	11380	9995	12557	29042	22099	25579
	2	3068	4343	3569	3910	3563	3856	2494	2810	2682	2846	3076	4054	7910
	3	828	1018	1016	902	655	886	565	755	775	666	595	963	806
	4	213	280	311	275	147	157	148	172	283	199	160	223	137
	5	81	68	109	98	109	43	50	68	61	94	65	81	105
	6	25	45	31	48	46	57	9	32	44	22	52	39	57
	7	12	12	30	6	25	29	42	3	23	30	7	38	26
	+gp	9	5	22	4	17	26	23	2	13	14	5	38	64
0	TOTAL	92835	61965	66567	89876	98336	52846	46081	43548	42687	78373	93514	82294	34684

5.5.4.1.3.3 XSA summary table.

Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECR Age 0	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 2-5
1998	64765	6524	1942	2429	1.251	0.7644
1999	39148	6410	2447	2413	0.986	0.8704
2000	46502	6266	2545	2297	0.9026	0.9459
2001	66657	6864	2288	2694	1.1774	1.1025
2002	69335	6882	1930	2726	1.4125	0.9528
2003	30839	5915	2111	2591	1.2271	1.3846
2004	31605	4089	1518	1301	0.8569	0.6841
2005	28325	4380	1673	1483	0.8864	0.7165
2006	28813	4661	1969	1599	0.8119	0.9914
2007	61944	5876	1811	1701	0.939	0.9557
2008	60512	6980	1617	2470	1.5277	0.6119
2009	54758	7784	2414	2260	0.9364	0.9503
Arith. Mean	48600	6053	2022	2164	1.0762	0.9109
0 Units	(Thousands	(Tonnes)	(Tonnes)	(Tonnes)		

5.5.5. Long term prediction

5.5.5.1. Justification

A yield per recruit analysis was conducted to estimate $F_{0.1}$ and F_{max} as proposed management reference points.

5.5.5.2. Input parameters

Fref (Fmean of ages 0-3 of the last year 2009)
F (estimated F over ages for 2009)

Table 5.5.5.2.1 Input parameters of the YpR analysis.

age min	age group	stock weight	catch weight	maturity	F	M	stock number
0	0	0.029	0.029	0.00	0.081	0.68	1
age max	1	0.118	0.118	0.00	0.557	0.47	
8	2	0.413	0.413	0.45	1.315	0.30	
Fref	3	0.892	0.892	0.98	1.729	0.22	
0.9207	4	1.428	1.428	1.00	0.569	0.19	
	5	2.051	2.051	1.00	0.188	0.17	
	6	2.539	2.539	1.00	0.241	0.16	
	7	3.162	3.162	1.00	0.037	0.15	
	8	3.619	3.619	1.00	0.037	0.14	
	9						
	10						
	11						
	12						
	13						
	14						
	15						
	16						
	17						
	18						
	19						

5.5.5.3. Results

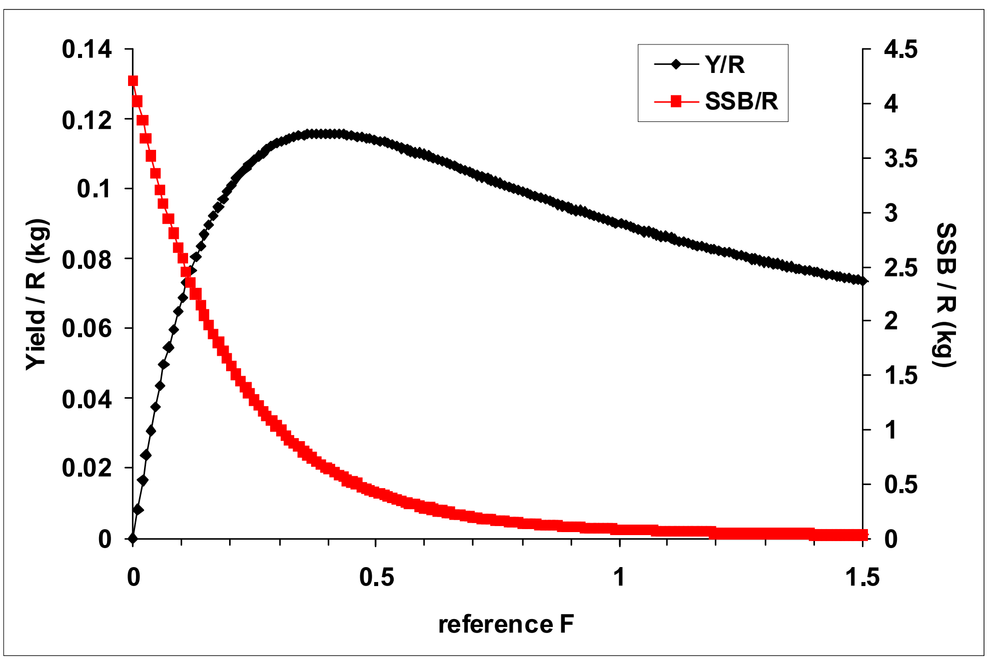


Fig. 5.5.5.3.1 YpR and SSBpR with increasing fishing mortality.

F_{max} = 0.396
$F_{0.1}$ = 0.267

5.5.6. Scientific advice

5.5.6.1. Short term considerations

5.5.6.1.1. State of the spawning stock size

The spawning stock shows no particular trend since 1998.

5.5.6.1.2. State of recruitment

Since 1998, 3 recruitments appear to be above average (1998, 2002 and 2007-2008).

5.5.6.1.3. State of exploitation

SGMED proposes the referent point $F_{0.1}$= 0.27 as a proxy for F_{msy}. The current F_{ref} is 0.92. SGMED considers that the stock is overexploited and recommends fishing mortality be reduced to the proposed reference point.

5.6. Stock assessment of hake in GSA 08

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.6.1. Stock identification and biological features

5.6.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.6.1.2. Growth

No information was documented during SGMED-10-02.

5.6.1.3. Maturity

No information was documented during SGMED-10-02.

5.6.2. Fisheries

5.6.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.6.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.6.2.3. Catches

5.6.2.3.1. Landings

No information was documented during SGMED-10-02.

5.6.2.3.2. Discards

No information was documented during SGMED-10-02.

5.6.2.3.3. Fishing effort

No information was documented during SGMED-10-02.

5.6.3. Scientific surveys

5.6.3.1. Medits

5.6.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were recalculated. SGMED-10-02 notes that the reported Medits data in GSA 08 only cover the eastern coast of Corsica. In GSA 08 the following number of hauls was reported per depth stratum (s. Tab. 5.6.3.1.1.1).

Tab. 5.6.3.1.1.1. Number of hauls per year and depth stratum in GSA 08, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA08_010-050	3															
GSA08_050-100	5	5	7	3	7	6	5	5		6	6	7	7	5	7	5
GSA08_100-200	3	5	4	2	5	5	5	5	1	5	5	5	5	3	5	4
GSA08_200-500	9	11	12	8	12	10	11	10		10	10	10	11	8	12	12
GSA08_500-800	5	5	4	4	4	5	4	5		4	5	5	4	5	4	3

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.6.3.1.2. *Geographical distribution patterns*

No analyses were conducted during SGMED-10-02.

5.6.3.1.3. *Trends in abundance and biomass*

Fishery independent information regarding the state of the hake in GSA 08 was derived from the international survey Medits. SGMED-10-02 notes that the reported Medits data in GSA 08 only cover the eastern coast of Corsica. Figure 5.6.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 08.

The estimated abundance and biomass indices do not reveal any significant trends since 1994. However, the recent abundance and biomass indices in 2009 appear low after a drop from a high value.

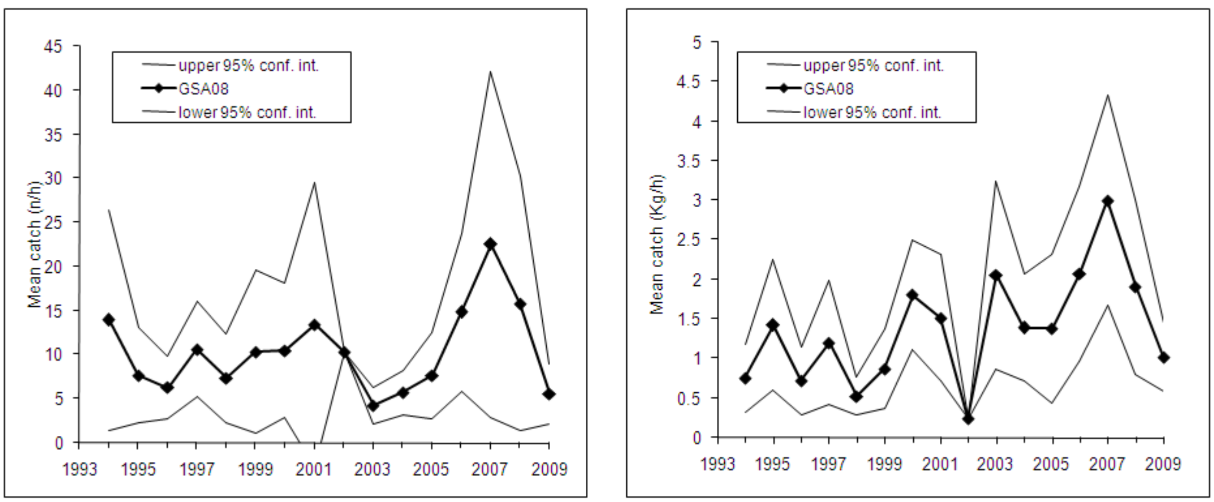


Fig. 5.6.3.1.3.1 Abundance and biomass indices of hake in GSA 08.

5.6.3.1.4. *Trends in abundance by length or age*

The following Fig. 5.6.3.1.4.1 and 2 display the stratified abundance indices of GSA 08 in 1994-2001 and 2002-2009.

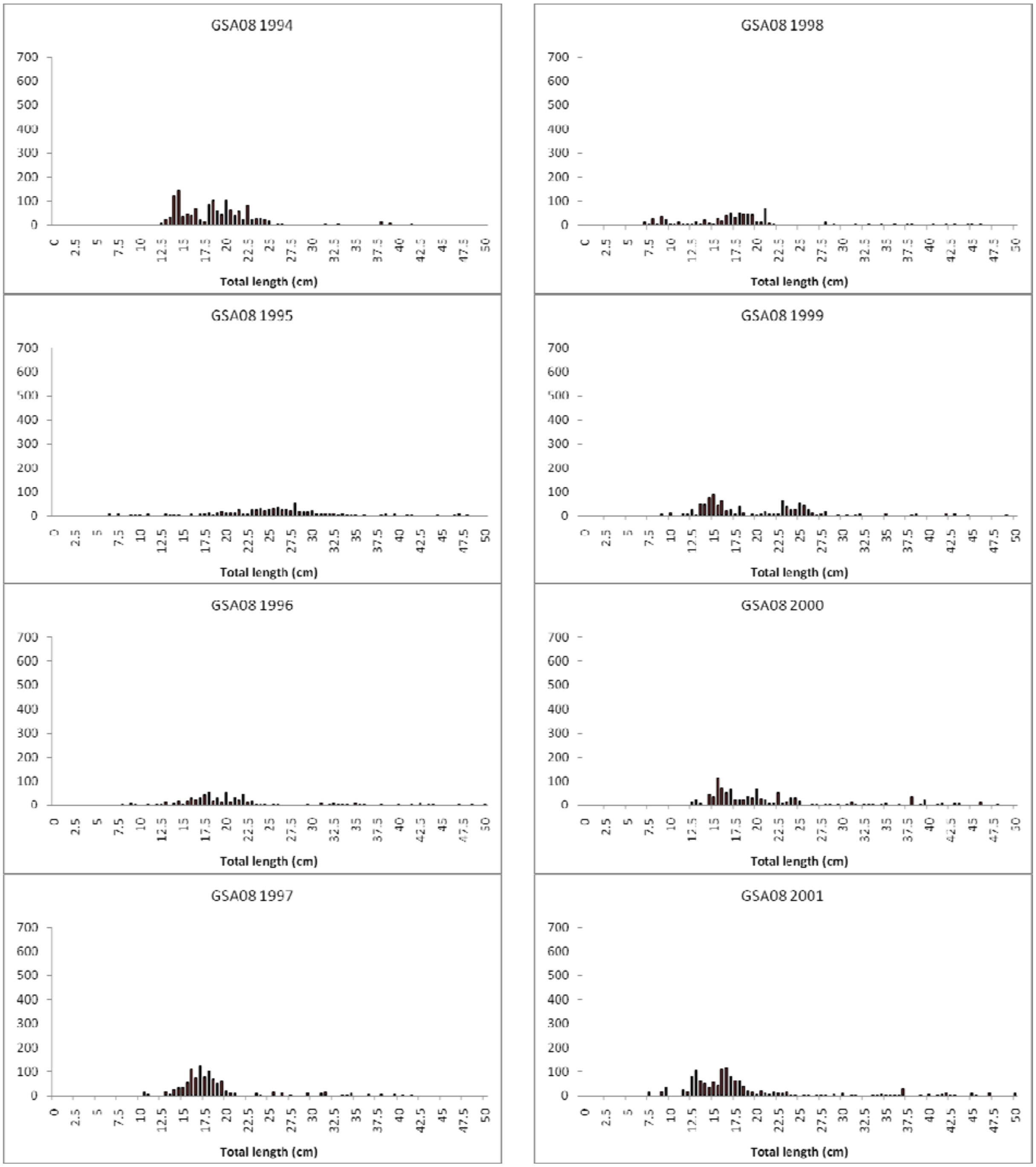


Fig. 5.6.3.1.4.1 Stratified abundance indices by size, 1994-2001.

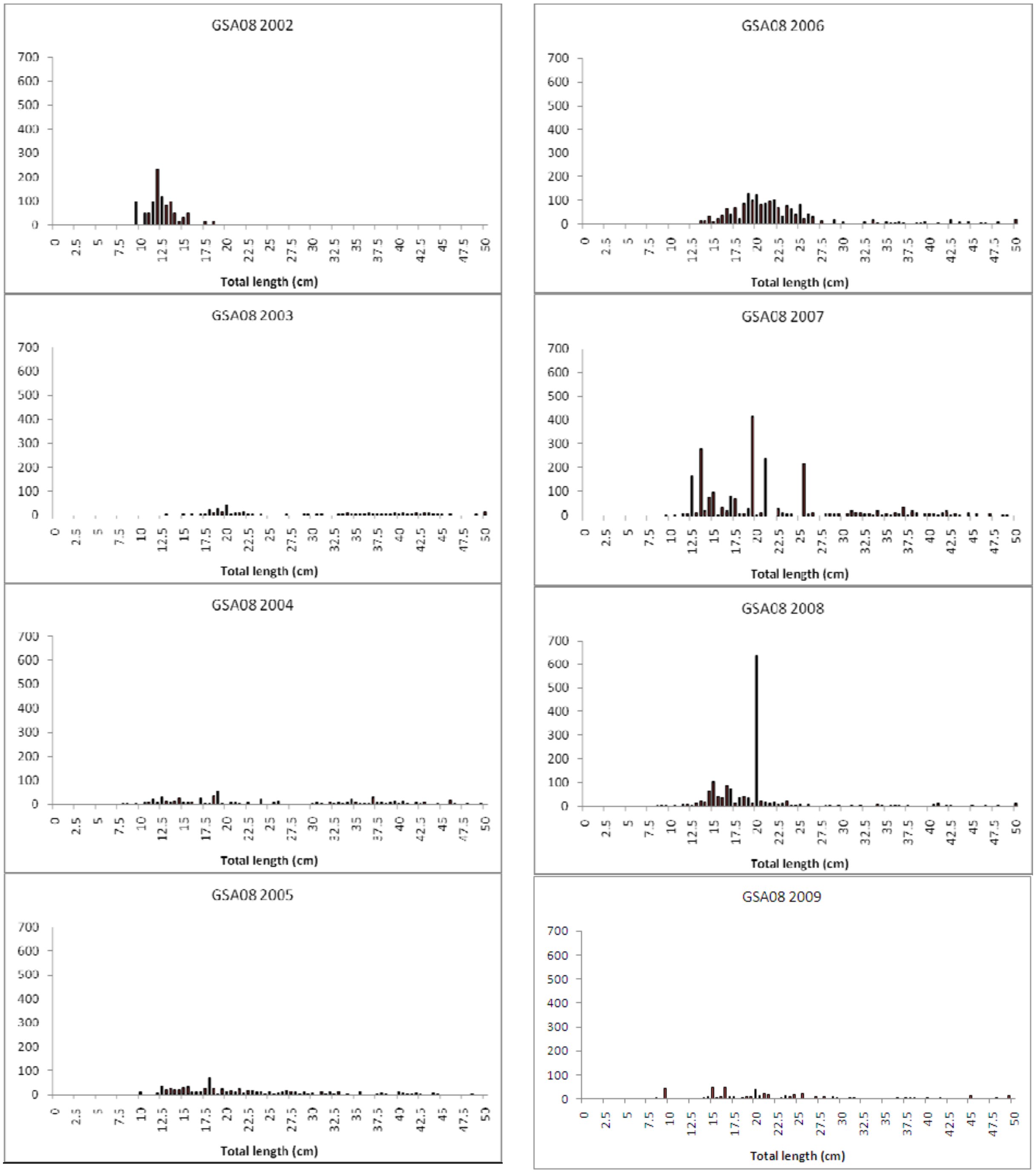


Fig. 5.6.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.6.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.6.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.6.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.6.5. Long term prediction

5.6.5.1. Justification

No forecast analyses were conducted.

5.6.5.2. Input parameters

No forecast analyses were conducted.

5.6.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for hake in GSA 08.

5.6.6. Scientific advice

5.6.6.1. Short term considerations

5.6.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.6.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.6.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation in relation to proposed precautionary and target levels given the preliminary state of the data and analyses.

5.7. Stock assessment of hake in GSA 09

5.7.1. Stock identification and biological features

5.7.1.1. Stock Identification

Due to a lack of information about the structure of hake population in the western Mediterranean, this stock was assumed to be confined within the GSA 09 boundaries.

Hake is distributed in the whole area between 10 and 800 m depth (Biagi et al., 2002; Colloca et al., 2003). Recruits peak in abundance between 150 and 250 m depth over the continental shelf-break and appear to move slightly deeper when they reach 10 cm total length. Crinoid (*Leptometra phalangium*) bottoms over the shelf-break are the main settlement habitat for hake in the area (Colloca *et al*., 2004, 2006; Reale *et al*., 2005). Migration from nurseries takes place when juveniles attained a critical size between 13 and 15.5 cm TL (Bartolino et al., 2008a). Maturing hakes (15-35 cm TL) persist on the continental shelf with a preference for water of 70-100 m depth, while larger hakes can be found in a larger depth range from the shelf to the upper slope. Juveniles show a patchy distribution with some main density hot spots (i.e. nurseries areas) showing a high spatio-temporal persistence (Abella *et al*., 2005; Colloca *et al*., 2006; 2009; Jona Lasinio *et al*., 2007) (Fig. 5.7.1.1.1) in areas with frontal systems and other oceanographic structures that can enhance larval retention (Abella *et al*., 2008).

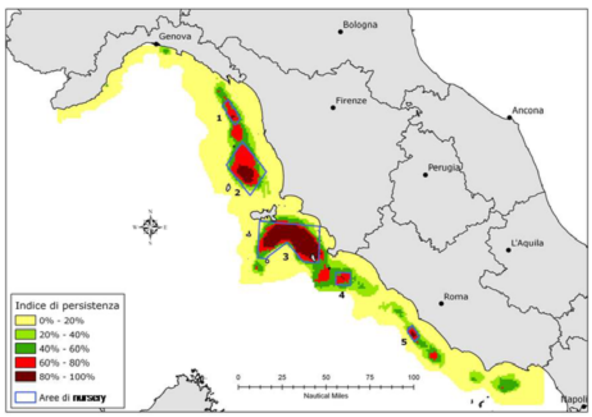
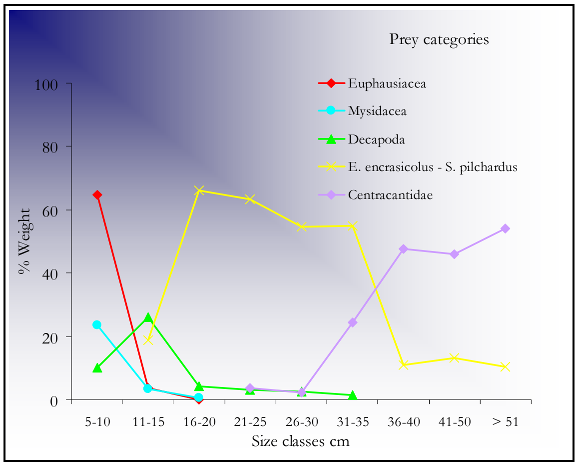
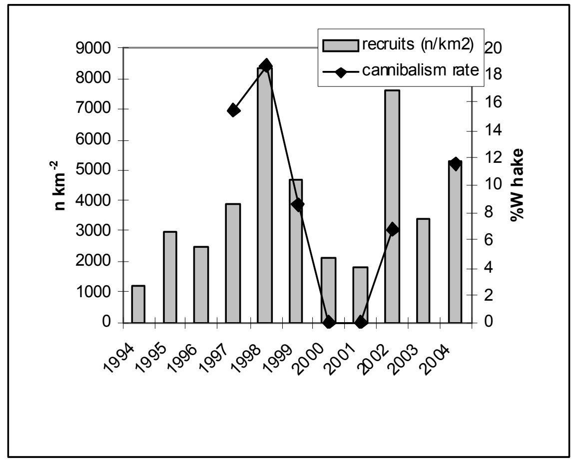


Fig 5.7.1.1.1 Temporal persistence of hake nurseries calculated from MEDITS and GRUND time-series density maps (1994-2005) of juveniles.

Although hakes are demersal fish feeding typically upon fast-moving pelagic preys while ambushed in the water column (Alheit and Pitcher, 1995), there is evidence that hakes feed in mid-water or at the surface during night-time, undertaking daily vertical migrations (Orsi-Relini *et al*., 1989, Carpentieri *et al*., 2008) which are more intense for juveniles. In GSA 09 many different studies are available on hake diet. Results from stomach data collected in the 1996-2001 period can be found in Sartor et al. (2003a) and Carpentieri et al. (2005). Hake diet shifts from euphausids and mysiids consumed by smaller hake (<16 cm TL), to fishes consumed by larger hake.

Before the transition to the complete ichthyophagous phase (TL> 36 cm) hake shows more generalized feeding habits where decapods, benthic (Gobiidae, *Callionymus* spp.,) and necktonic fish (*S. pilchardus, E. encrasicolus*) dominated the diet, whereas cephalopods had a lower incidence (Fig. 5.7.1.1.2).





A) B)

Fig. 5.7.1.1.2 A) Hake diet composition in GSA 09 by size class (from Carpentieri *et al*., 2005). B) Relationships between recruitment and cannibalism rate (proportion by weight, %W, of hake in hake stomachs).

Estimation of cannibalism rate has been provided for the southern part of the GSA (Latium, EU Because project). Cannibalism increased with size and can be considered significant for hakes between 30 and 40 cm TL (up to 20% by weight in diet) and seems to relate closely to hake recruitment density and level of spatial overlapping.

Consumption rate has been estimated for juveniles and piscivorous hakes. Daily consumption of juveniles, calculated in proportion of body weight (%BW), varied between 5 (July) and 5.9 % BW (Carpentieri et al., 2008). The estimated relative daily consumption for hake between 14 and 40 cm TL, using a bioenergetic approach (EU Because project), was between 2.9 and 2.3 BW%.

5.7.1.2. Growth

Juvenile growth rate was estimated to be about 1.5 cm.month^{-1} using daily growth increments on otoliths (Belcari et al., 2006). According to this growth rate, hake reaches an average length of about 18 cm TL at the end of the first year. According to these observations, the growth of hake in the GSA 09 seems to follow the pattern estimated in the NW Mediterranean (Garcia-Rodriguez and Esteban, 2002) adopting the hypothesis that two rings are laid down on otoliths each year. This new interpretation of otolith ring patterns returns a growth rate (L_∞ = 103.9, K/year = 0.212, t_0 =0.031) almost double than that assumed in the past.

As showed in the Fig. 5.7.1.2.1, cohorts obtained through age slicing of LFDS MEDITS data according to fast growth parameters, can be consistently followed during time, while a less reliable pattern was obtained using parameters conform to the slow growth hypothesis.

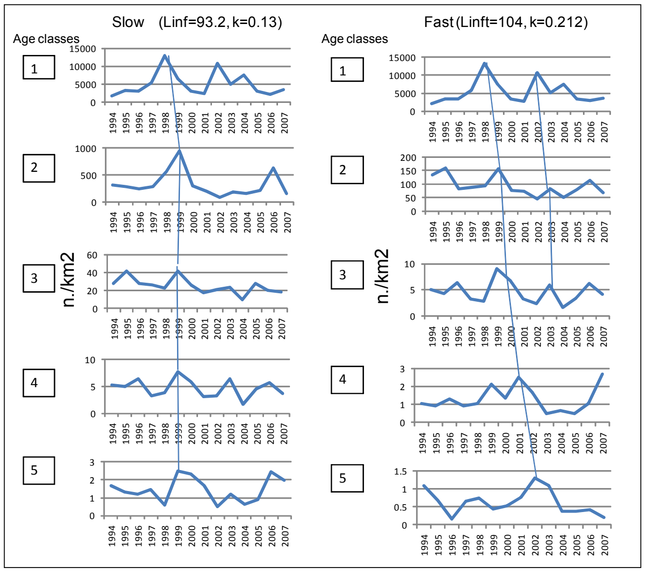


Fig. 5.7.1.2.1 Trends in abundance of age classes obtained using age slicing according to two different sets of growth parameters on MEDITS data.

5.7.1.3. Maturity

The catchability of hake spawners to the Mediterranean trawl nets is rather limited. The distribution of adults which are more abundant on deeper or untrawable grounds, or the ability of larger fish to avoid capture have been claimed as causes of the observed extremely reduced catch of adult hake by trawlers in the Mediterranean (Abella *et al.*, 1997). Also during trawl surveys (MEDITS and GRUND) the catch rate of mature specimens was very low, reducing the possibility of use trawl survey data to explore patterns in gonad development as well as the relationships between growth rate and maturation processes.

Large size hake are targets of a specifically targeted gillnet fishery carried out by several vessels working in the southern part (northern and central Tyrrhenian Sea) of the GSA 09 (Sartor *et al.*, 2001a).

Reproductive biology and fecundity of hake have been studied in northern Tyrrhenian Sea (Biagi *et al.*, 1995; Nannini *et al.*, 2001; Recasens *et al.*, 2008) by monthly samplings of adults caught by trawling and gillnets.

Females in advanced maturity stages, spawning and partial post-spawning are present all year round, but reproductive activity is concentrated from January to May, with two peaks of spawning in February and May. The presence of hake spawners seems to be more concentrated in the southern part of GSA 09.

Female length at first maturity was estimated at 35 cm TL in northern Tyrrhenian Sea (Recasens *et al.*, 2008). This value is consistent with the observations obtained from trawl surveys over the Latium (Colloca, pers. comm.) reporting first maturity from 31 to 37 cm TL for females and from 21 to 25 cm TL for males.

Batch fecundity was about 200 eggs per gonad-free female gram, with asynchronous oocyte development (Recasens *et al.*, 2008).

5.7.2. Fisheries

5.7.2.1. General description of fisheries

Hake is among the most important component of bottom trawlers targeting a species complex and is the demersal species providing the highest landings and incomes for the GSA 09. The analysis of available information suggests that about 90% of landings of hake are obtained by bottom trawl vessels; the remaining fraction is provided by artisanal vessels using set nets, in particular gillnets.

The trawl fleet of GSA 09 at the end of 2006 accounted for 361 vessels (Tab. 5.7.2.1.1).

The main trawl fleets of GSA 09 are present in the following continental harbours: Viareggio, Livorno, Porto Santo Stefano (Tuscany), Fiumicino, Terracina, Gaeta (Latium).

Tab. 5.7.2.1.1 Technical characteristics of the trawl fleet of GSA 09.

N. of boats	361
GT	13.191
kW	75.514
Mean GT	36.5
Mean kW	209.2

As concerns fishing activity, the majority of bottom trawlers of GSA 09 operate daily fishing trips with only some vessels staying out for two-three days and especially in summer.

Hake fishing grounds comprise all the soft bottoms of continental shelves and the upper part of continental slope. Fishing pressure shows some geographical differences inside the GSA 09 according to the consistency of the fleets and the characteristics of the bottoms.

The artisanal fleets, according to the last official data (end of 2006), accounted for 1,309 vessels that operate in several harbours along the continental and insular coasts. Of these, about 50 vessels, mainly located in some harbors of the GSA 09 (e.g. Marina di Campo, Ponza, Porto Santo Stefano), utilize gillnets and target medium and large-sized hakes (larger than 25 cm TL) especially from winter to summer.

5.7.2.2. Management regulations applicable in 2009and 2010

- Fishing closure for trawling: 45 days in late summer (not every year have been enforced)
- Minimum landing sizes: EC regulation 1967/2006: 20 cm TL for hake.
- Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets will be replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.
- Two small No Take Zones (“Zone di Tutela Biologica”, ZTB) are present inside the GSA 09; one off the Giglio Island (50 km^2, northern Tyrrhenian Sea) another off Gaeta, (125 km^2, central Tyrrhenian Sea). Bottom fishing was not allowed in the two ZTB. A recent regulation of the Italian Ministry of Agricultural, Food and Forestry Policies established that fishing activities can be carried out in these two areas from July 1st to December 31st.

5.7.2.3. Catches

5.7.2.3.1. Landings

In the last seven years the total landings of hake of GSA 09 fluctuated between 1,000 to about 2,300 tons (Fig. 5.7.2.3.1.1). Landings from 2009 were not submitted by the Italian authorities.

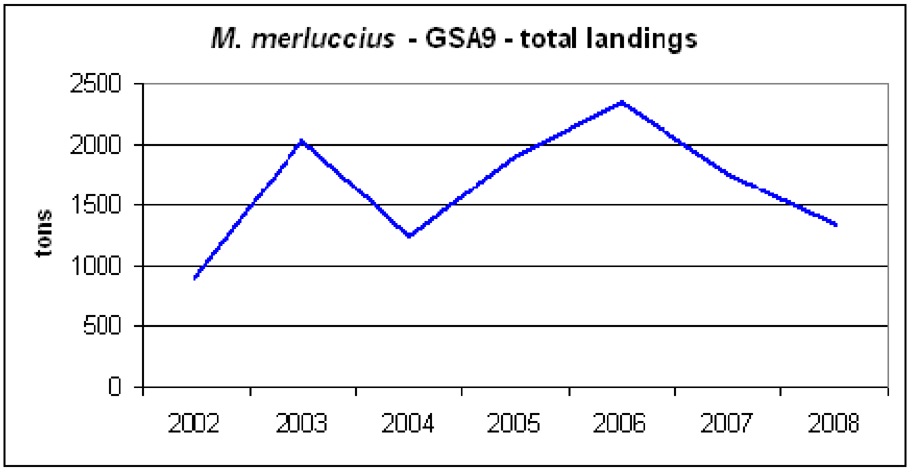


Fig. 5.7.2.3.1.1 Landings of hake (all gears) in the GSA 09, from 2002 to 2008 (DCR official data).

Due to huge concentration of hake juveniles in GSA 09, trawl landings were traditionally dominated by small sized specimens; they are basically composed by 0+ and 1+ age class individuals. Gillnet fishery lands mostly 2+ and 3+ years old fishes, as shown, as an example, by the two following histograms (Fig. 5.7.2.3.1.2).

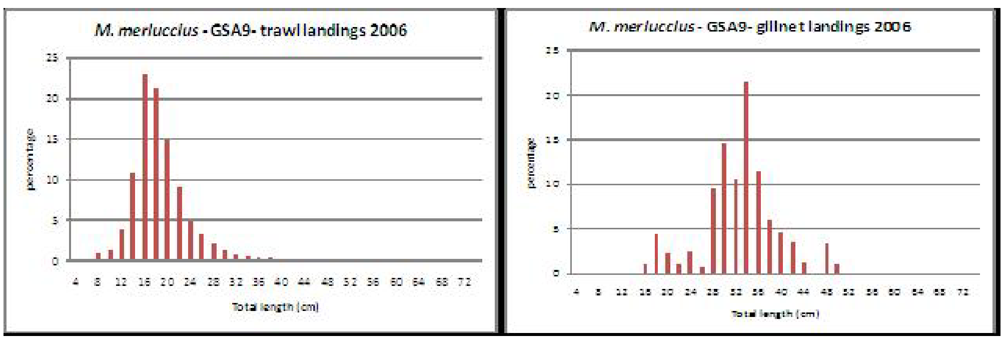


Fig. 5.7.2.3.1.2 Size structure of the landings of hake provided in 2006 by otter trawling and by set nets in the GSA 09 (DCR official data).

The following Table 5.7.2.3.1.1 lists the landings data of Hake in GSA 09 coming from the Data Collection Regulation, by major gear types.

According to the STECF-SGMED-10-02 scientist's knowledge, DCR landing data for GSA 09 give an overstimation of the amount derived from the set nets. This aspect underlines both the need of some improvements of the data collection, paying particular attention to the sampling design and the importance of a routinely check made by experts of the official data.

Table 5.7.2.3.1.1 Landings (t) by year and major gear types, 2004-2008 as reported through DCF. No data for 2002 and 2003 were submitted.

Gear	2004	2005	2006	2007	2008
Bottom trawls	553	1054	1180	1025	915
Longlines	4	11	142	16	5
Miscellaneous	40	20	4		
Nets	596	835	1002	712	410
Seines	2		0		
Surrounding nets	0		3		
Totale complessivo	1195	1920	2330	1753	1330

5.7.2.3.2. Discards

Several EU and national projects carried out in GSA 09 highlighted the problem of discard of hake by trawl fisheries. High quantities of small sized hakes are routinely discarded, especially in summer and on the fishing grounds located near the main nursery areas of the species (Fig. 5.7.2.3.2.1).

Due to the introduction of the EU Regulations on MLS a progressive increase of the size at which 50% of the specimens caught was discarded has been observed in these last years: from about 11 cm TL in 1995 (Sartor *et al*., 2001b), to about 17 cm TL in 2006 (De Ranieri, 2007). In the last years this size is even increasing (Sartor, pers. obs.) This phenomenon might be also explained with the reduction of the fishing pressure on the nursery areas of this species.

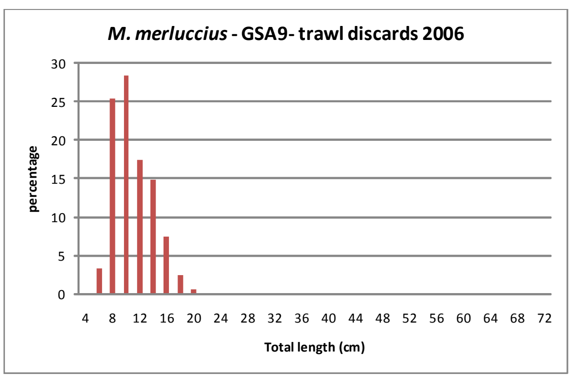


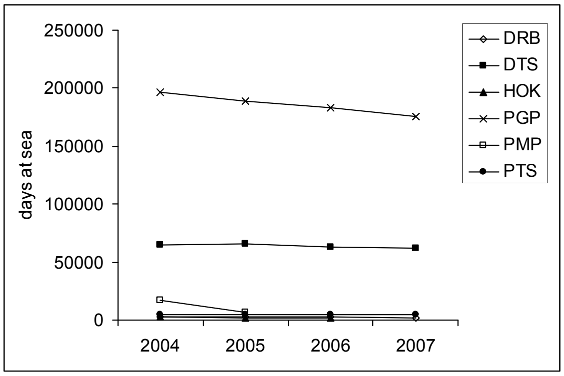
Fig. 5.7.2.3.2.1 Size structure of the hake discarded by the trawl fleets operating in the GSA 09 in 2006 (DCR official data).

Reported discards through the DCR data call to SGMED-09-02 amount 467 t in 2006 for trawlers.

5.7.2.3.3. Fishing effort

The fishing capacity of the GSA 09 has shown in these last 10 years a progressive decrease; from 1996 to 2007.

The total fishing days carried out by all the GSA 09 trawlers varied from about 65,000 in 2004 to about 63,000 in 2006 (Fig. 5.7.2.3.3.1), a little decrease of the mean number of fishing days/year per vessel was observed in this period, from 187 to 177.



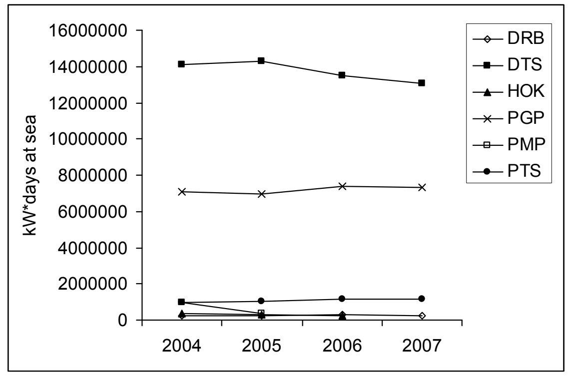


Fig. 5.7.2.3.3.1 Effort trends (days and kW*days) by major fleets, 2004-2007.

Tab. 5.7.2.3.3.1 Effort trends (kW*days) by major fleets as reported through DCF (no data available in 2002, 2003 and 2009).

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
9	ITA				VL0006					296		
9	ITA				VL0612		31025	45782	71302	4865	12129	
9	ITA	DRB	MOL		VL1218		18652	20370	13504	29808	28266	
9	ITA	GNS	DEMSP		VL0006				14365	9687	7681	
9	ITA	GNS	DEMSP		VL0612		204925	219978	146971	201390	146006	
9	ITA	GNS	DEMSP		VL1218		100498	59006	49194	62666	67944	
9	ITA	GNS	SLPF		VL0612		4857				3707	
9	ITA	GTR	DEMSP		VL0006				1417	4451		
9	ITA	GTR	DEMSP		VL0612		75571	121141	100767	142363	43116	
9	ITA	GTR	DEMSP		VL1218		3222	19168	11102	14510	6610	
9	ITA	LLD	LPF		VL0612		6569	17394	3581	5904	25890	
9	ITA	LLD	LPF		VL1218		1611	4427	24956	5535	12094	
9	ITA	LLS	DEMF		VL0612		37454	75215	18823	4330		
9	ITA	LLS	DEMF		VL1218		3914	9998				
9	ITA	LTL	LPF		VL0006				3198	687		
9	ITA	OTB	DEMSP		VL0612		7282	6524	15126	21176	14595	
9	ITA	OTB	DEMSP		VL1218		118419	113284	77407	171295	221969	
9	ITA	OTB	DEMSP		VL1824		515183		69690	200680	478813	
9	ITA	OTB	DEMSP		VL2440		125282					
9	ITA	OTB	MDDWSP		VL1218		151739	183842	177083	158561	57869	
9	ITA	OTB	MDDWSP		VL1824		85625	737780	692516	404814	75728	
9	ITA	PS	SPF		VL0612			10014				
9	ITA	PS	SPF		VL1218			3703				
9	ITA	PS	SPF		VL1824		6526	6055				
9	ITA	SB-SV	DEMSP		VL0006				3780	3664	4506	
9	ITA	SB-SV	DEMSP		VL0612		127810	191056	133213	74903	62000	
9	ITA	SB-SV	DEMSP		VL1218		22438	10582	13566	2988	5196	

5.7.3. Scientific surveys

5.7.3.1. MEDITS

5.7.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 09 the following number of hauls were reported per depth stratum (s. Tab. 5.7.3.1.1.1).

Tab. 5.7.3.1.1.1. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA09_010-050	19	18	18	18	19	18	18	18	13	13	13	14	13	13	13	14
GSA09_050-100	19	20	18	19	18	19	20	20	15	15	15	14	16	16	13	14
GSA09_100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	28	27
GSA09_200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	30	28
GSA09_500-800	31	30	31	28	30	28	27	29	24	22	21	20	20	17	18	20

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.7.3.1.2. Geographical distribution patterns

According to recent studies (Orsi Relini et al., 2002), the density of hake recruits concentrations in nursery areas in GSA 09 is by far higher than that of the other GSAs of the western Mediterranean and, probably, also of the other Mediterranean GSAs (Fig. 5.7.3.1.2.1).

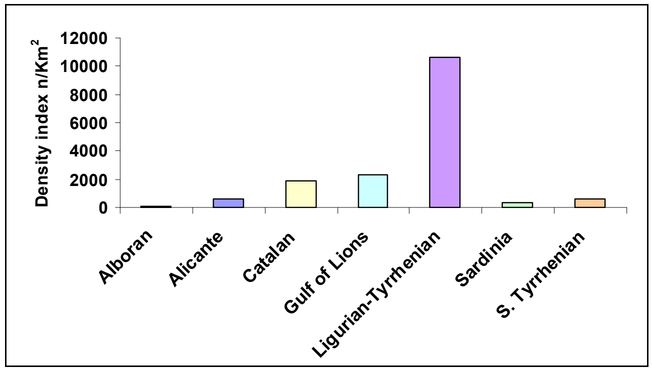


Fig. 5.7.3.1.2.1 MEDITS density indices of the hake recruits (<12 cm TL) obtained in different Mediterranean GSAs (from Orsi-Relini et al., 2002, modified).

Generalized additive models were developed to investigate hake recruitment dynamics in the Tyrrhenian Sea in relation to spawner abundance and selected key oceanographic variables. Thermal anomalies in summer, characterized by high peaks in water temperature, revealed a negative effect on the abundance of recruits in autumn, probably due to a reduction in hake egg and larval survival rate. Recruitment was reduced when elevated sea-surface temperatures were coupled with lower levels of water circulation. Enhanced spring primary production, related to late winter low temperatures could affect water mass productivity in the following months, thus influencing spring recruitment. In the central Tyrrhenian a dome-shaped relationship between wind mixing in early spring and recruitment could be interpreted as an “optimal environmental window” in which intermediate water mixing level played a positive role in phytoplankton displacement, larval feeding rate and appropriate larval drift (Bartolino *et al*., 2008b) (Fig. 5.7.3.1.2.2).

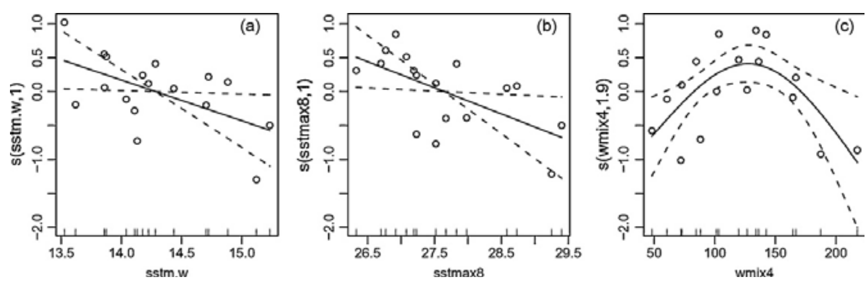


Fig. 5.7.3.1.2.2 Effects of: (a) sstm.w, (b) sstmax8 and (c) wmix4 on hake recruitment in the central Tyrrhenian (from Bartolino et al., 2008b).

The temporal trend in spatial distribution of hake > 26 cm TL showed a clear reduction of distribution area, particularly in the Tyrrhenian part of the GSA (GRUND data, Fig. 5.7.3.1.2.3).

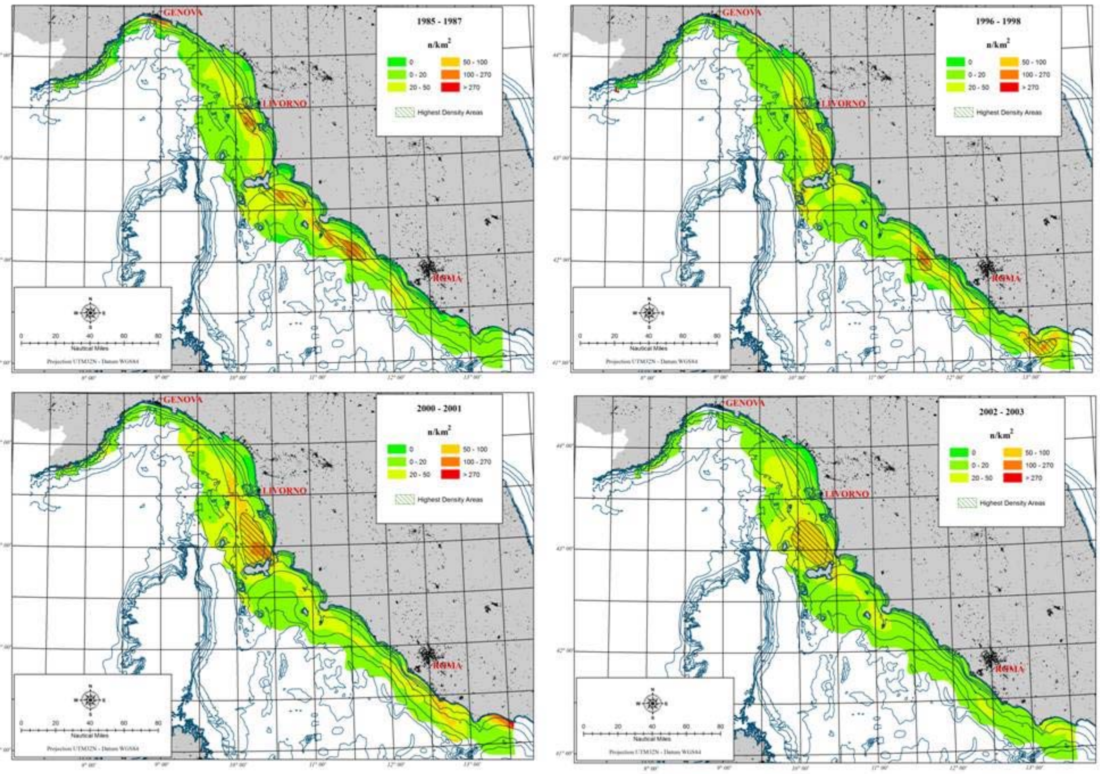


Fig. 5.7.3.1.2.3 Distribution of hakes larger than 26 cm TL in 1985-87, 1996-98, 2000-01, 2002-03.

5.7.3.1.3. Trends in abundance and biomass

The national GRUND trawl survey (Relini, 1998) has been performed out along the Italian coasts in addition to MEDITS. It has been carried out since 1985, with some years lacking (1988, 1989 and 1999, 2007). Sampling is random stratified, except in the period 1990-93 where a different sampling design, based on transects, was applied. Locations of stations were selected randomly within each stratum in the period 1985-87, while starting from 1996, the same stations were sampled the following years. Therefore from 1994 in Italy two trawl surveys are regularly carried out each year: MEDITS, in spring, and GRUND, in autumn. The two surveys provide integrate pictures on different seasons, allowing to monitor the most important biological events (recruitment, spawning) for the majority of the demersal species.

Figure 5.7.3.1.3.1 shows the density and biomass indices of hake obtained from 1994 to 2008; no evident trends are present.

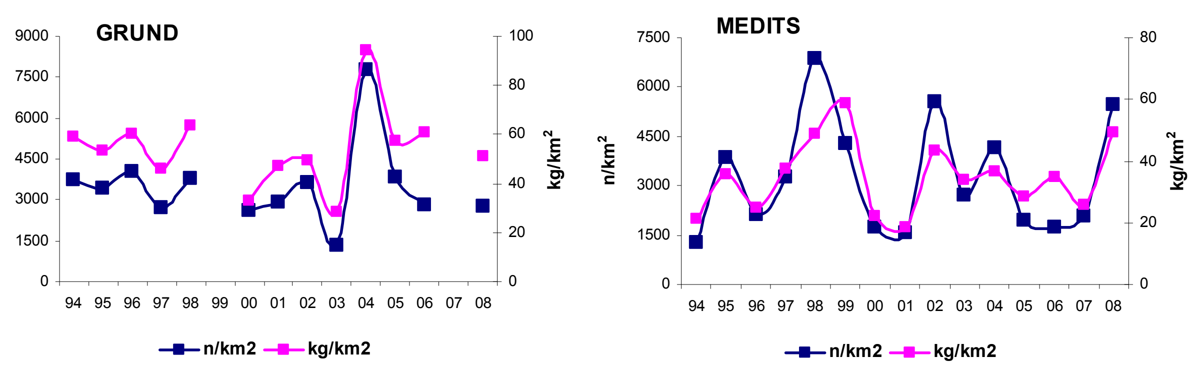


Fig. 5.7.3.1.3.1 Density and biomass indices of hake according to the GRUND and MEDITS surveys.

Figure 5.7.3.1.3.2 displays the re-estimated trend in hake abundance and biomass in GSA 09 (kg/h) based on the MEDITS DCR data call. Both MEDITS trends presented are similar without any long term trend.

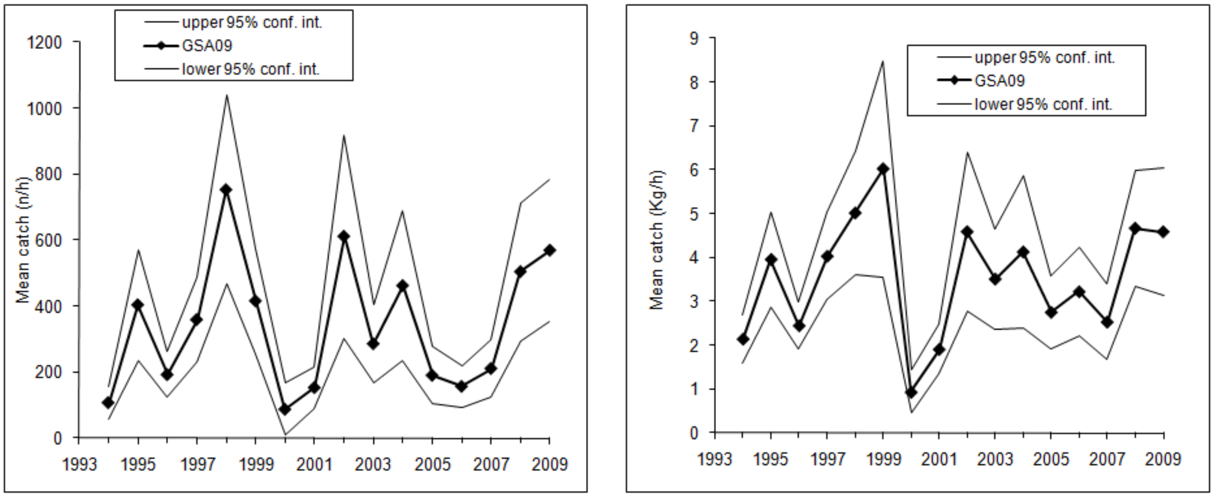


Fig. 5.7.3.1.3.2 Abundance and biomass indices of hake in GSA 09.

5.7.3.1.4. Trends in abundance by length or age

The following Fig. 5.7.3.1.4.1 and 2 display the stratified abundance indices of GSA 09 in 1994-2001 and 2002-2009.

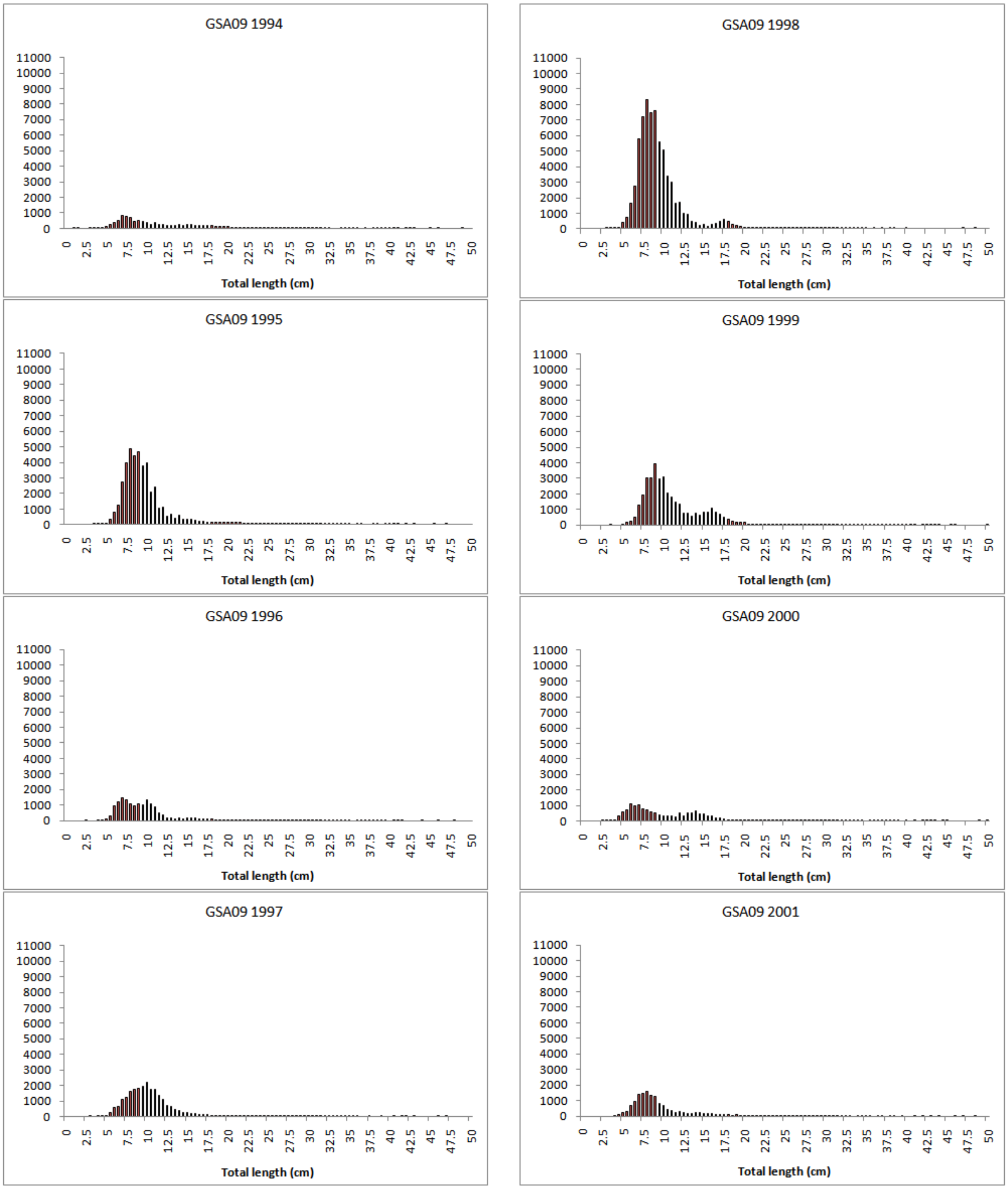


Fig. 5.7.3.1.4.1 Stratified abundance indices by size, 1994-2001.

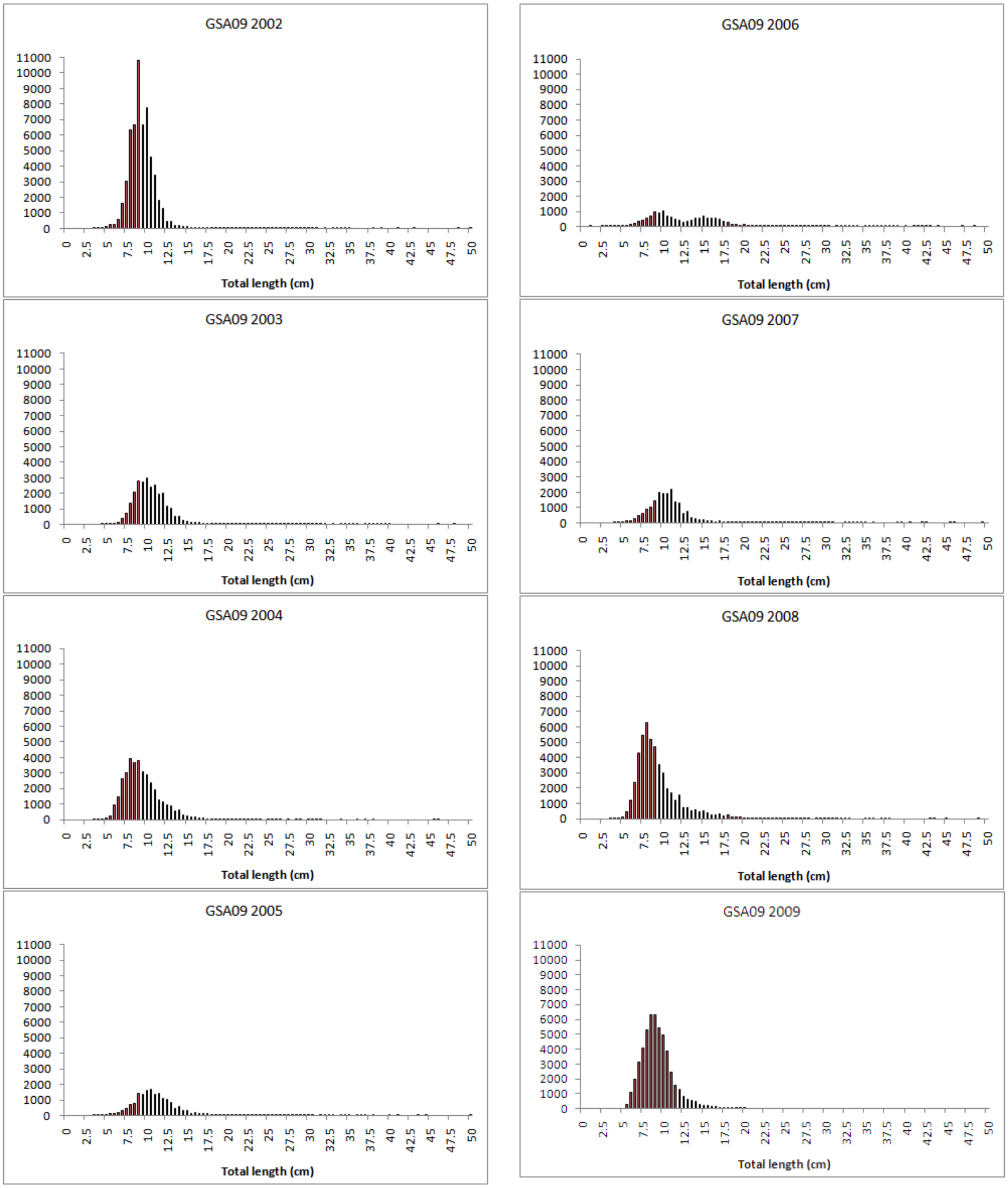


Fig. 5.7.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.7.3.1.5. Trends in growth

No analyses were conducted.

5.7.3.1.6. Trends in maturity

No analyses were conducted.

5.7.4. Assessment of historic stock parameters

Due to its importance as demersal resource, hake has been object of several assessments in the GSA 09 (Reale *et al*., 1995; Fiorentino et al., 1996; Ardizzone et al., 1998; Abella *et al.*, 1999; 2007; Colloca *et al*., 2000). These results are published and regularly updated in the GFCM SAC sheets. The assessments, often performed with different approaches in different periods or in different subareas of the GSA 09, showed substantially convergent results.

The hake in the GSA 09 seems to be in a "chronic" overexploitation, as shown by the results of the analytical models (reference points as F_{max}, $F_{0.1}$ and SSB_{curr}/SSB_0). Also the production models based on total mortality provided total mortality estimates greater than the mortality corresponding to the maximum biological production (ZMBP).

A growth overfishing situation was detected, with excessive fishing mortality on 0+ and 1+ age classes. The values of the SSB_{curr}/SSB_0 ratio are always lower than 0.1.

Two new assessments based on DCF landing data and survey data (MEDITS and GRUND) were produced using Length Cohort Analysis (LCA) and SURBA respectively during STECF-SGMED-09-02. SURBA assessment was updated including 2009 MEDITS data in the time series during STECF-SGMED-10-02. The lack of 2009 landings data for GSA 9 during the meeting makes it impossible to perform a new LCA assessment for this stock.

5.7.4.1. Method 1: Trends in LPUE

As concerns the Landings per Unit of Effort, quite long time series are available for some important fleets operating in this GSA 09.

5.7.4.1.1. Justification

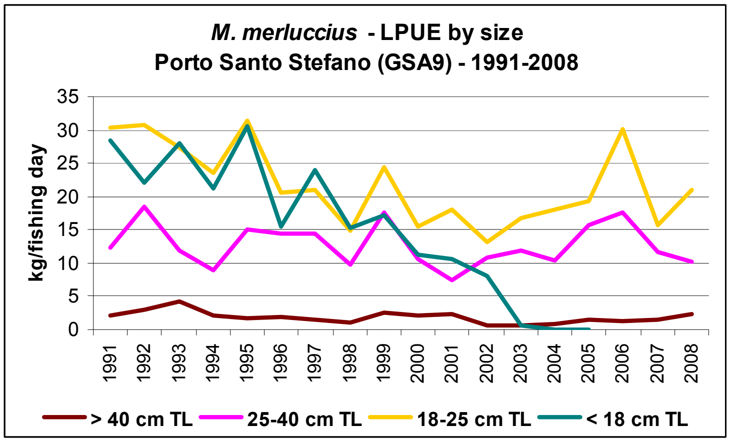
Trends in LPUE may provide insight into trends in stock size. SGMED-10-02 recommends that technological creep should be considered when trends in LPUE are interpreted.

5.7.4.1.2. Input parameters

These data come from independent monitoring activities performed by the research institutes working in the GSA.

5.7.4.1.3. Results

As an example, the LPUE evolution in the period 1991-2008 is reported in Fig. 5.7.4.1.3.1. LPUE showed a continuous decreasing trend till 2004 while LPUE remained substantially stable in the last four years. The decrease in LPUE is mainly due to a change in fishing pattern experienced by the local fleets: the progressive disappearance of the smallest specimens from the landings is the effect of the introduction of the EU Regulations (1626/94 and 1967/06) concerning MLS (20 cm TL for hake). Also a progressive reduction of fishing pressure on the nursery areas is occurring in the last years, especially on the northern fishing grounds of GSA 09.



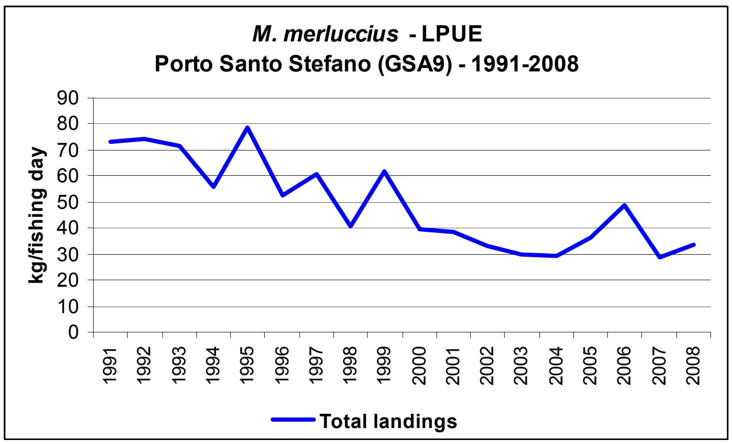


Fig. 5.7.4.1.3.1 Hake LPUE of the Porto Santo Stefano trawl fleet (1991-2008); above: LPUE by size class; below: total LPUE

5.7.4.2. Method 2: SURBA

5.7.4.2.1. Justification

The relatively long time series of data available from the GRUND and MEDITS surveys provided the most useful data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used both on MEDITS (1994-2009) and GRUND (1994-2004) data of the hake of GSA 09.

5.7.4.2.2. Input parameters

The following set of parameters was adopted:

Growth parameters (Von Bertalanffy)
$L\infty$ = 104 (mm, length)
K = 0.2
t_0 = - 0.03

L*W
a = 0.006657
b = 3.028
Natural mortality
M vector Age_1=1.3 , Age_2=0.6, Age_3=0.46, Age_4=0.41, Age_5=0.3
Catchability (q)
q(age 0+) = 0.8, q(age 1+) = 1.0, q(age 2+)=0.7, q(age3+)=0.7, q(age 4+)=0.7
Length at maturity (L50)
L50 = 30 cm
Length of first capture (Lc)
Lc = 12 cm

Tab. 5.7.4.2.2.1 Input parameters used for the SURBA model.

MEDITS						GRUND				
Mean abundance										
	Age					Age				
Year	0	1	2	3	4+	0	1	2	3	4+
1994	2062.6	132.4	5	1.1	1.1	4079.4	111.5	6.5	0.1	0.3
1995	3446.2	159.5	4.3	0.9	0.7	3586.1	132.0	3.2	0.6	0.3
1996	3366.3	80.9	6.3	1.3	0.2	3930.0	157.9	4.5	1.1	0.6
1997	5753.5	86.4	3.3	0.9	0.7	2729.1	119.9	4.0	0.9	0.7
1998	13371	94.8	2.9	1	0.7	3894.3	122.9	4.4	0.7	0.3
1999	7441.3	156.7	9	2.2	0.4	3265.3	103.9	5.0	0.6	0.5
2000	3371	75.3	6.8	1.4	0.5	2636.3	84.9	5.6	0.6	0.7
2001	2663.1	73.8	3.3	2.5	0.7	3254.5	126.2	4.0	0.8	0.4
2002	10864	44.7	2.3	1.7	1.3	3901.0	107.8	3.9	0.8	0.5
2003	5153	82	6	0.5	1.1	1243.5	102.7	4.4	0.7	0.7
2004	7590.5	51.1	1.6	0.6	0.4	7859.5	110.5	3.3	0.9	0.6
2005	3278.9	79.3	3.4	0.5	0.4					
2006	2865	114	6.2	1.1	0.4					
2007	3559.8	69.1	4.2	2.7	0.2					
2008	8529	94.8	3.6	1	1					
2009	5121.2	60.855	1.905	0.357	0.1					
Proportion mature										
	Age									
Year	0	1	2	3	4+	0	1	2	3	4+
1994	0	0.012	0.96	1	1	0	0	0.012	0.96	1
1995	0	0.012	0.92	1	1	0	0.012	0.92	1	1
1996	0	0.029	0.9	1	1	0	0.029	0.9	1	1
1997	0	0.02	0.94	1	1	0	0.02	0.94	1	1
1998	0	0.017	0.89	1	1	0	0.017	0.89	1	1
1999	0	0.015	0.92	1	1	0	0.015	0.92	1	1
2000	0	0.026	0.92	1	1	0	0.026	0.92	1	1
2001	0	0.018	0.96	1	1	0	0.018	0.96	1	1
2002	0	0.028	0.97	1	1	0	0.028	0.97	1	1
2003	0	0.025	0.93	1	1	0	0.025	0.93	1	1
2004	0	0.012	0.9	1	1	0	0.012	0.9	1	1
2005	0	0.027	0.92	1	1					
2006	0	0.021	0.93	1	1					
2007	0	0.019	0.96	1	1					
2008	0	0.019	0.96	1	1					
2009	0	0.02	0.94	1	1					
Mean weights										
	Age									
Year	0	1	2	3	4+	0	1	2	3	4+
1994	0.008	0.086	0.498	1.244	3.261	0.013	0.113	0.461	0.875	1.794
1995	0.006	0.091	0.491	1.205	3.031	0.013	0.112	0.488	0.912	2.885
1996	0.006	0.103	0.452	1.455	2.122	0.012	0.108	0.454	1.051	1.834
1997	0.007	0.097	0.519	1.340	2.918	0.013	0.114	0.420	1.095	1.954
1998	0.005	0.091	0.489	1.509	2.630	0.015	0.105	0.438	1.021	1.952
1999	0.009	0.090	0.451	1.292	2.036	0.012	0.110	0.449	1.026	1.919
2000	0.008	0.105	0.475	1.153	2.136	0.009	0.116	0.458	1.032	1.904
2001	0.006	0.094	0.580	1.180	2.839	0.012	0.112	0.438	1.108	2.359
2002	0.005	0.114	0.513	1.335	2.522	0.011	0.111	0.445	1.060	2.118
2003	0.007	0.100	0.509	1.269	2.509	0.015	0.117	0.420	0.986	1.596
2004	0.006	0.087	0.491	1.345	2.233	0.011	0.112	0.447	1.113	2.245
2005	0.009	0.101	0.448	1.052	3.447					
2006	0.013	0.088	0.505	1.286	3.307					
2007	0.007	0.096	0.505	1.286	3.307					
2008	0.007	0.096	0.559	1.220	2.000					
2009	0.0074	0.0964	0.5593	1.225	1.8109					

5.7.4.2.3. Results

Fitted year effect, that is the model proxy for the combination of fishing effort and mean natural mortality in the underlying population, shows peaks in 1999, 2003 and 2009 following recruitment peaks with a time lag of one year. Fitted age effect shows a decreasing from age 0 to age 2, while fitted cohort effects (Figure 5.7.4.2.3.1) show large fluctuations.

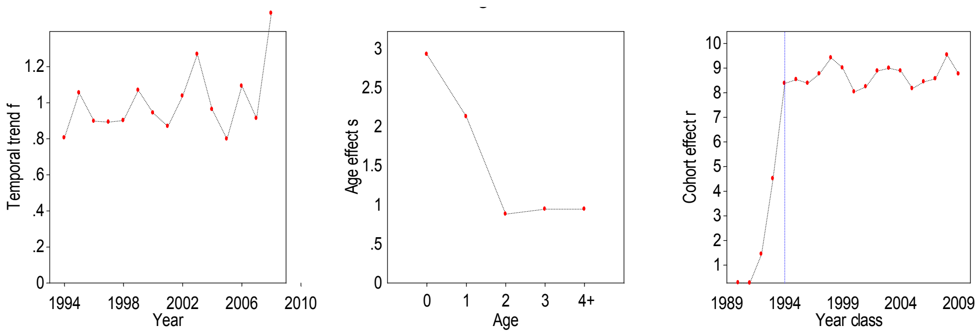


Fig. 5.7.4.2.3.1 MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.

The two surveys gave a similar picture for F_{1-3} which shows a clear increasing trend (MEDITS, $p<0.01$) from 0.8 (1994) to 2.4 (2009). Relative SSB decreased significantly (MEDITS, $p<0.01$). Recruitment fluctuated from year to year without a clear temporal pattern during MEDITS. The largest year classes were observed in 1998 and 2008. GRUND showed a more constant pattern in recruitment with the lowest value in 2003 and a high peak in 2004 (Fig. 5.7.4.2.3.2).

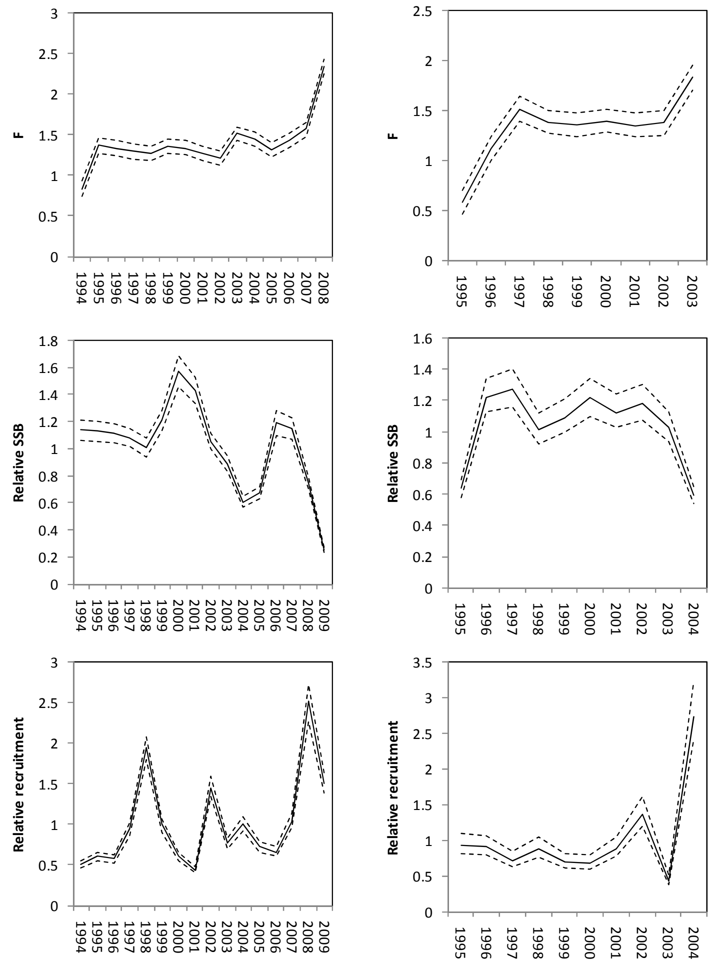


Fig. 5.7.4.2.3.2 MEDITS and GRUND surveys. Estimated trend in F, relative SSB and recruitment using SURBA. 50th percentile of bootstrapped runs (solid line) and 5% and 95% percentiles of bootsrapped runs (dashed lines).

Model diagnostics are shown in the following Fig. 5.7.4.2.3.3 and Fig. 5.7.4.2.3.4.

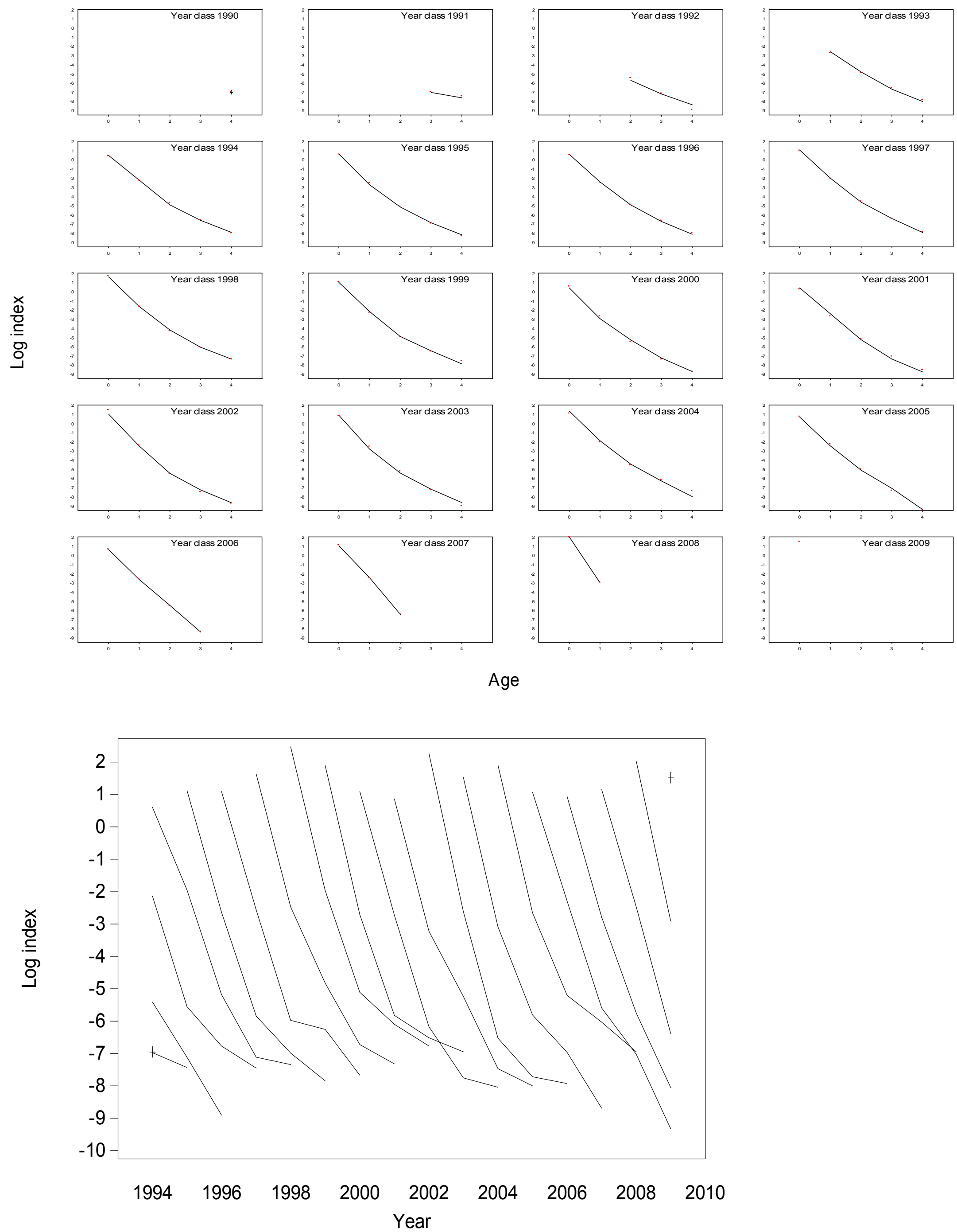


Fig. 5.7.4.2.3.3 Model diagnostic for SURBA model in the GSA 09 (MEDITS data). A) Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.

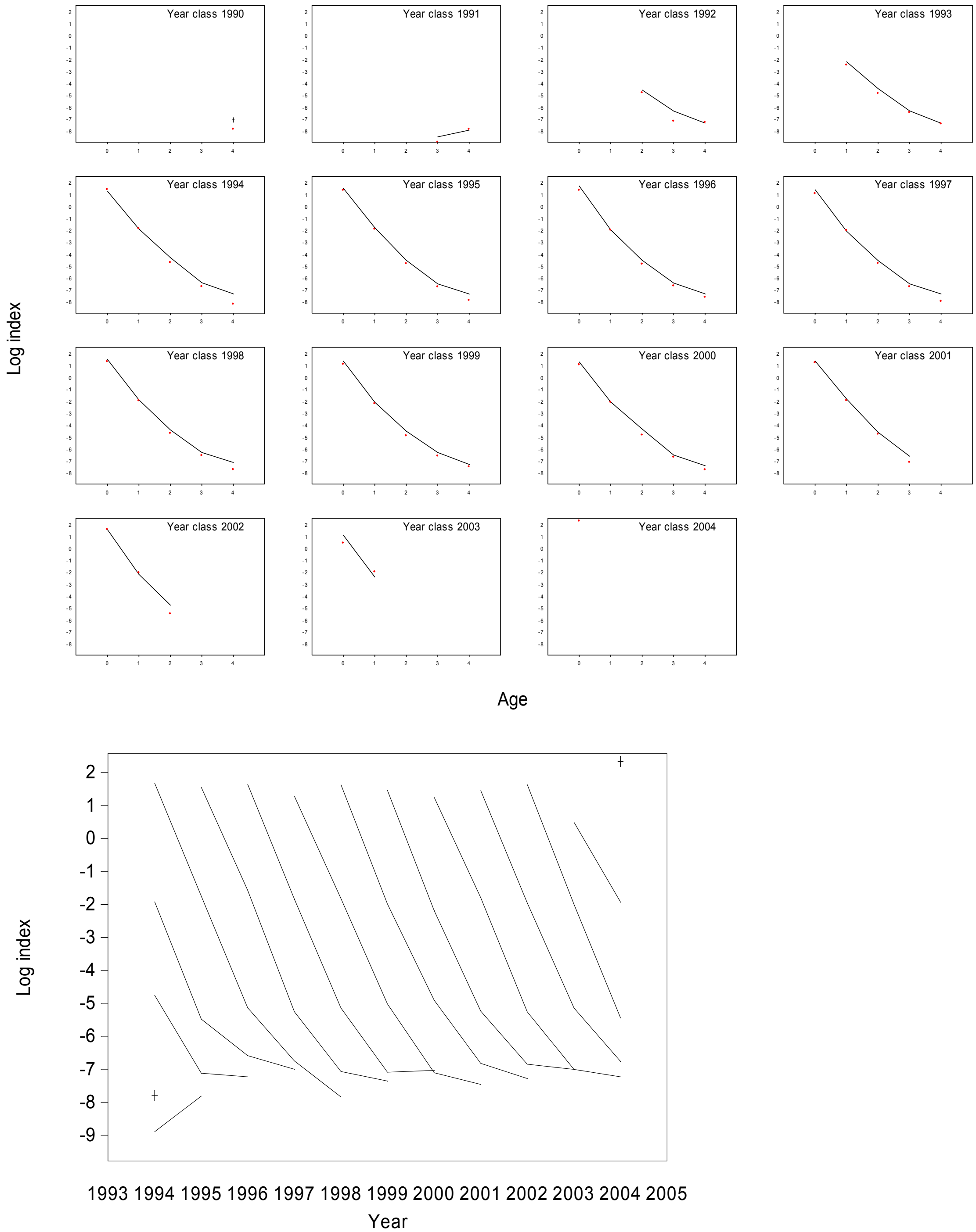


Fig. 5.7.4.2.3.4 Model diagnostic for Surba SURBA model in the GSA 09 (Grund GRUND data). A) Comparison between observed (points) and fitted (lines) of survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.

5.7.4.3. Method 3: LCA on DCR data

5.7.4.3.1. Justification

Assessment was performed using an LCA (VIT software, Lleonart and Salat, 1997) on an annual pseudocohort (year 2006 and 2008). Landings from 2009 were not submitted by the Italian authorities, thus SGMED was not able to carry out an update of the VIT analysis.

5.7.4.3.2. Input parameters

Data coming from DCR contained, for GSA 09, information on hake landings and the respective size/age structure for the period 2005-2008; discard size structure was also available but only for 2006. Such data were available for the two main fishing gears exploiting hake in GSA 09: trawling and set nets (gillnets). Anyway, the short data series did not allow the use of VPA models.

LCA was performed using VIT software on data of the years 2006 and 2008. For 2006, landings data were "corrected" including the available information on discards. Fig. 5.7.4.3.2.1 shows the size frequency distributions of the landings and discards, by gear.

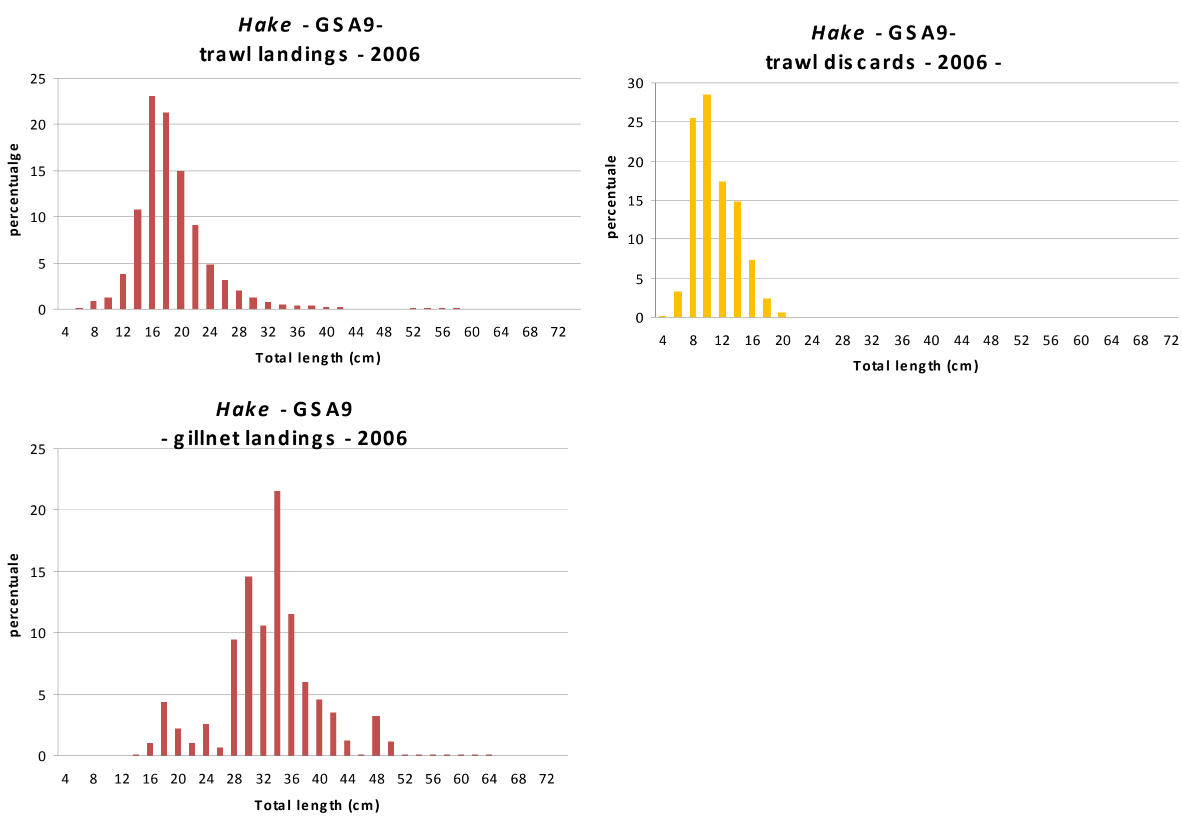


Fig. 5.7.4.3.2.1. Length frequency distributions of the *M. merluccius* landings and discards in 2006 in the GSA 09.

Tab. 5.7.4.3.2.1 shows the input data concerning 2006. The used parameters were the same of the SURBA analysis, including the same M-vector and the same maturity ogive.

Tab. 5.7.4.3.2.1. Input data for LCA of the European hake in GSA 09.

	Data are in percentage	
Total length (CM)	BOTTOM TRAWL Landings + discards	GILLNETS Landings
4	0.0595	0.0000
6	2.6588	0.0000
8	20.4007	0.0000
10	22.8540	0.0000
12	14.5735	0.0000
14	14.0674	0.0638
16	10.6385	1.0094
18	6.2978	4.3835
20	3.5836	2.2102
22	1.8927	1.0732
24	0.9992	2.5426
26	0.6632	0.7016
28	0.4215	9.4687
30	0.2611	14.6433
32	0.1472	10.6057
34	0.1039	21.5582
36	0.0793	11.5010
38	0.0712	5.9670
40	0.0535	4.5749
42	0.0467	3.4882
44	0.0101	1.2645
46	0.0053	0.0638
48	0.0045	3.2331
50	0.0017	1.1370
52	0.0369	0.0638
54	0.0164	0.1276
56	0.0164	0.1276
58	0.0164	0.0638
60	0.0113	0.1276
62	0.0078	0.0801
64	0.0078	0.0801
66	0.0078	0.0401
68	0.0037	0.0010
70	0.0078	0.0000
72	0.0036	0.0000

	BOTTOM TRAWL	GILLNETS
LANDINGS (tons)	1180	131
	BOTTOM TRAWL	
DISCARDS	465	

According to the STECF-SGMED-10-02 scientist's knowledge, DCR landing data for GSA 09 have been adjusted concerning the contribution of artisanal fishery to the total catch. DCR data gave a proportion of about 60% for trawling and about 40% for set nets. An overestimation of the set nets was detected, so the percentage contribution of set nets was reduced to a more realistic value of 10%, taking into account the expert's knowledge of the GSA 09 fisheries. This aspect underlines both the need of some improvements of the data collection, paying particular attention to the sampling design and the importance of a routinely check made by experts of the official data.

5.7.4.3.3. Results

The general results of LCA highlight an exploitation focused on young age classes, mainly 0+ and 1+, reflecting a growth overfishing state. As concerns 2006 data a mean value of F(1-3) of 1.24 was estimated, while for the 2008 data a value of 1.53 was obtained. Fig. 5.7.4.3.3.1 shows, as an example, the results of 2006.

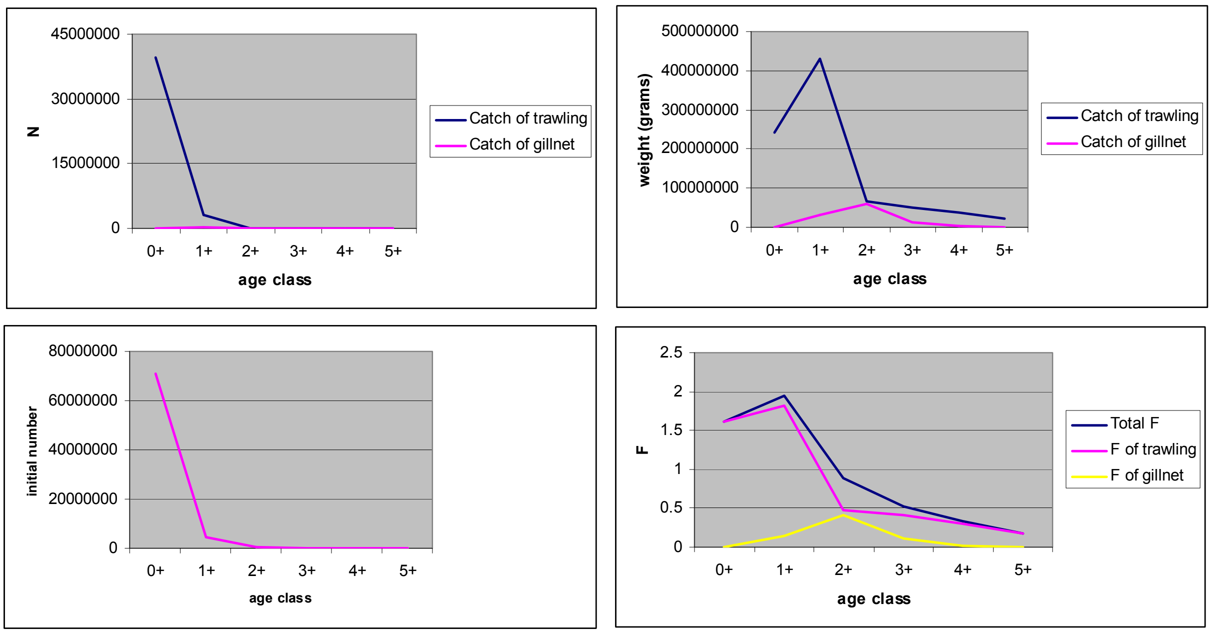


Fig. 5.7.4.3.3.1. LCA outputs: catch in numbers, catch in weight, numbers-at-age and fishing mortality at age of *M. merluccius* in the GSA 09 (2006 data).

5.7.5. Long term prediction

5.7.5.1. Justification

Equilibrium YPR reference points for the stock estimated through the Yield software (Hoggarth *et al*., 2006) were assessed. Further YPR analyses were conducted based on the VIT (pseudocohort) results.

5.7.5.2. Input parameters

Equilibrium YPR reference points for the stock were estimated through the Yield software (Hoggarth *et al.*, 2006) assuming recruitment fluctuating randomly around a constant value and 20% uncertainty in input parameters. The second YPR analyses used the results of VIT (pseudocohort) as inputs. The used parameters were the same of the SURBA and LCA analyses given above.

5.7.5.3. Results

Yield software quantified uncertainty by repeatedly selecting a set of biological and fishery parameters by sampling from the probability distributions for uncertain parameters set by the user, and then calculating the quantities of interest. In this sampling, it is assumed that each of the uncertain parameters are independently distributed, even though for some biological parameters, this assumption is almost certainly incorrect (Hoggarth *et al*., 2006). F_{max} and F_{ref} , this latter corresponding to F at SSB/initial SSB = 0.30, were assumed as limiting reference points. $F_{0.1}$ was assumed as target reference point. The probability distributions of the three RPs showed a considerable variations (Fig. 5.7.5.3.1). The following mean values were obtained: F_{max} = 0.35; $F_{0.1}$= 0.22 and F_{ref} = 0.28. The maximum predicted values were respectively 0.59 (F_{max}), 0.36 (F_{01}) and 0.41 (F_{ref}). RPs suggest an overfishing situation for the stock considering current F about six times higher than the limit and target RPs F.

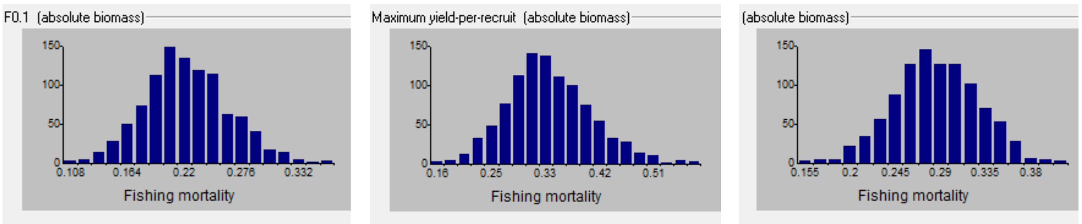


Fig. 5.7.5.3.1 Probability distribution of hake RPs in the GSA 09 obtained using the Yield software (age groups 1-5).

Fig. 5.7.5.3.2. shows the YPR analysis performed with VIT software with DCR data of 2006. A similar picture was obtained with 2008 data. With the forecasting routine of VIT, due to the fact of the use of a M vector declining with age, a higher value of F_{max} and $F_{0.1}$ can be obtained and a better exploitation status of the stock is derived, even though still high regarding the mentioned F reference values.

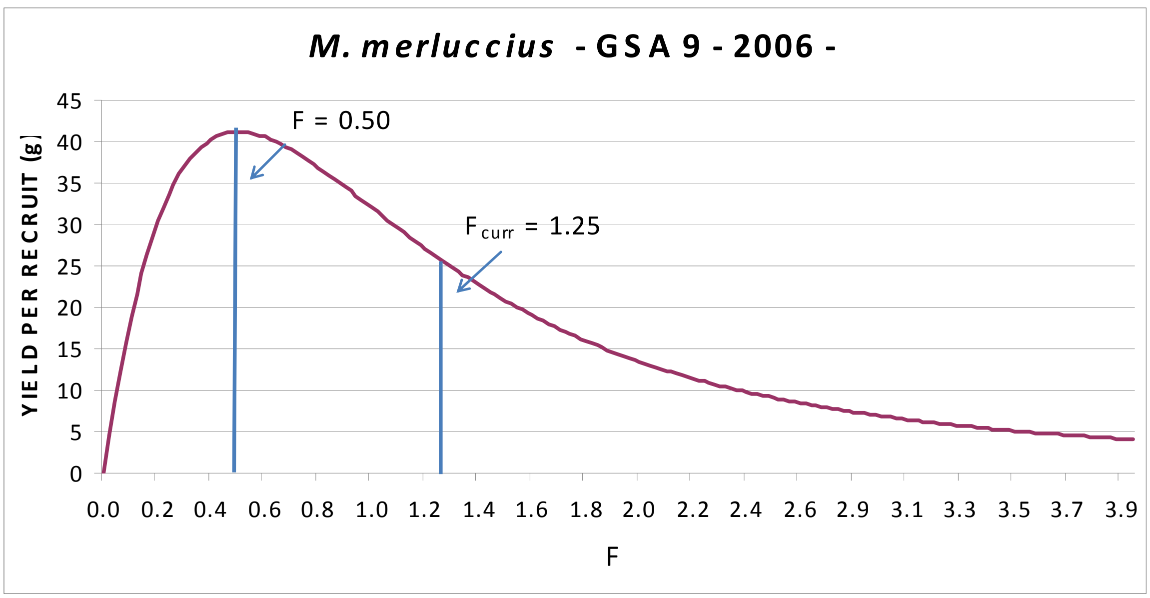


Fig. 5.7.5.3.2 Y/R curves from VIT analyses. F values (age groups 1-5) are also shown.

5.7.6. Data quality

MEDITS survey data were available from 1994. A check of hauls allocation between GSA 09 and 10 needs to be done before calculation of indices from MEDITS database. Landing data for 2009 were not available during SGMED-10-02, while effort data seem not consistent with previous estimates for the GSA. Landings from 2009 were not submitted by the Italian authorities. Due to lack of numbers-at-age or numbers-at-length from the landings, the update of the VIT assessment in 2009 was not carried out.

5.7.7. Scientific advice

5.7.7.1. Short term considerations

5.7.7.1.1. State of the spawning stock size

From the above reported analyses, SSB in 2009 was likely to amount to 5-10% of the SSB at F_{msy}. STECF SGMED-10-02 underlines that this conclusion could be influenced by the observed exploitation patterns in the surveys and fisheries, which almost exclusively represent the juvenile part of the stock.

5.7.7.1.2. State of recruitment

In recent years recruitment has varied without a clear trend.

5.7.7.1.3. State of exploitation

The stock appeared heavily overexploited in 2008 and F needs a consistent reduction from the current F towards the candidate reference points for long term sustainability based on F around $F_{0.1}$ (0.2). However, considering the high productivity in terms of incoming year classes, this stock has the potential to recover quickly if F is reduced towards F_{msy}. The continued lack of older fish in the surveyed population indicates exploitation rates far beyond those considered consistent with high yields and low risk. An improvement of the estimates of catchability of adults is needed to better estimate the stock dynamics and to assess the likely impact of fishing activity on this stock.

5.8. Stock assessment of hake in GSA 10

5.8.1. Stock identification and biological features

5.8.1.1. Stock Identification

The stock of European hake was assumed in the boundaries of the whole GSA 10, lacking specific information on stock identification. *M. merluccius* is with red mullet and deep-water pink shrimp a key species of fishing assemblages in the central-southern Tyrrhenian Sea (GSA 10). It is generally also ranked among species with higher abundance indices in the trawl surveys (e.g. Spedicato et al. 2003). It is a long lived fish mainly exploited by trawlers, especially on the continental shelves of the Gulfs (e.g. Gaeta, Salerno, Palermo) but also by artisanal fishers using fixed gears (gillnets, bottom long-line).

Trawl-survey data have evidenced highest biomass indices on the continental shelf of the GSA 10 (100-200 m; Spedicato et al., 2003), where juveniles (less than 12 cm total length) are mainly concentrated. During autumn trawl surveys, one of the main recruitment pulses of this species is observed. Two main recruitment events (in spring and autumn; Spedicato et al. 2003) are reported in GSA 10 as for other Mediterranean areas (Orsi Relini *et al*., 2002). European hake is considered fully recruited to the bottom at 10 cm TL (from Samed, 2002). The length structures from trawl surveys are generally dominated by juveniles, while large size individuals are rare. This pattern might be also due to the different vulnerability of older fish (Abella and Serena, 1998) besides the effect of high exploitation rates. The few large European hake caught during trawl surveys are generally females and inhabit deeper waters. The overall sex ratio (~0.41-0.47) estimated from trawl survey data is slightly skewed towards males.

5.8.1.2. Growth

Estimates of growth parameters were achieved during the Samed project (SAMED, 2002) by the analysis of length frequency distributions. The following von Bertalanffy parameters were estimated by sex: females L_∞=74.2 cm; K=0.178; t_0= -0.20; males: L_∞=46.3cm; K=0.285; t_0= -0.20.

In the DCF framework the growth has been studied ageing fish by otolith readings using the whole sagitta and thin sections for older individuals. Length frequency distributions were also analyzed using techniques as Bhattacharya for separation of modal components. The observed maximum length of European hake was 83 cm for females and 58 cm for males both registered in the landings (bottom long-lines). Von Bertalanffy growth parameters for each sex were estimated from average length at age using an iterative non-liner procedure that minimizes the sum of the square differences between observed and expected values (excel): females: L_∞=97.9 cm, K=0.135, t_0= -0.4; males: L_∞=50.8 cm, K=0.25, t_0= -0.4. Parameters of the length-weight relationship were a=0.00350, b=3.2 for females and a=0.0086, b=3.215 for males, for length expressed in cm (Fig. 5.8.1.2.1).

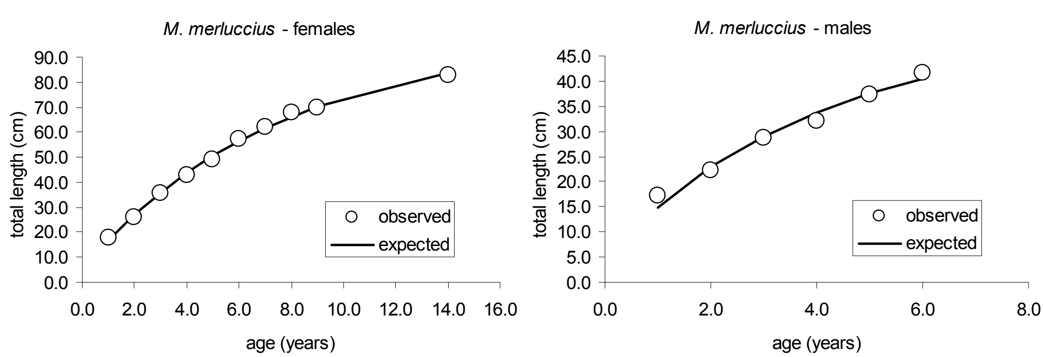
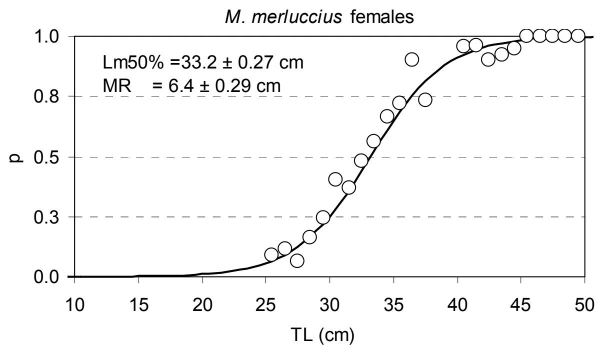


Fig. 5.8.1.2.1. V. Bertalanffy growth functions for females and males of hake in the GSA 10.

5.8.1.3. Maturity

A proxy of size at first maturity was estimated in the Samed project (SAMED, 2002) using the average length at stage 2 (females with gonads at developing stage) that indicates an average length of about 30 cm. According to the data obtained in the DCF of 2008, the proportion of mature females (fish belonging to the maturity stage 2b onwards macroscopically classified using a 8 stage scale (Medits-Handbook_2007.v5) by length class in the period 2006-2008 is reported in the table below together with the estimated maturity ogive which indicates a $L_{m50\%}$ of about 33 cm (±0.27 cm) (Fig. 5.8.1.3.1). These estimates are similar to those of 2003-2005 ($L_{m50\%}$=32.9±0.8; MR=6.4±0.9).



Proportion of mature females			
TL (cm)	p	TL (cm)	p
20	0.023	29	0.243
21	0.021	30	0.403
22	0.011	31	0.37
23	0.012	32	0.483
24	0.06	33	0.563
25	0.091	34	0.667
26	0.114	35	0.722
27	0.063	36	0.903
28	0.164	37	0.735

Fig. 5.8.1.3.1 Maturity ogive and proportions of mature female of hake in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio is about 1:1 up to the size of 35 cm, after females are prevailing (Fig. 5.8.1.3.2).

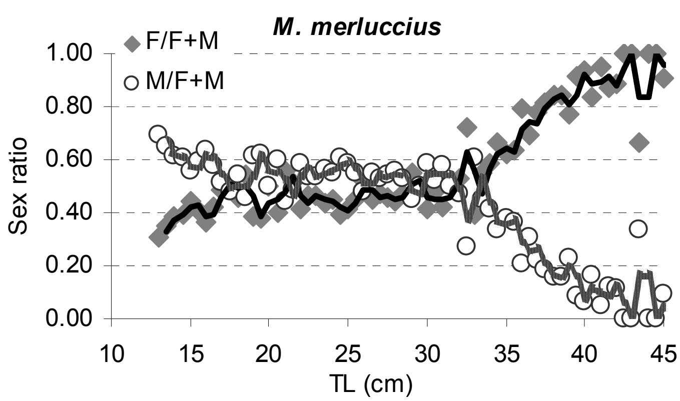


Fig. 5.8.1.3.2 Sex ratio for females and males by length.

5.8.2. Fisheries

5.8.2.1. General description of fisheries

European hake is mostly targeted by trawlers, but also by small scale fisheries using nets and bottom long-lines. Fishing grounds are located along the coasts of the whole GSA, offshore 50 m depth or 3 miles from the coast. Catches from trawlers are from a depth range between 50-60 and 500 m and hake occurs with other important commercial species as *Illex coindetii*, *M. barbatus*, *P. longirostris*, *Eledone* spp., *Todaropsis eblanae*, *Lophius* spp., *Pagellus* spp., *P. blennoides*, *N. norvegicus*.

5.8.2.2. Management regulations applicable in 2010

Management regulations are based on technical measures as closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties. After 2000, in agreement with the European Common Fisheries Policy, a gradual decreasing of the fleet capacity is implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990. Two closed areas were also established in 2004 along the mainland, in front of Sorrento peninsula (Napoli Gulf) and Amantea (Calabrian coasts), although these protected area mainly cover the distribution of coastal species. Other measures include technical measures (mesh size) and minimum landing sizes (EC 1967/06). In the GSA 10 the fishing ban has not been mandatory along the time, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it was mandatory. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

5.8.2.3. Catches

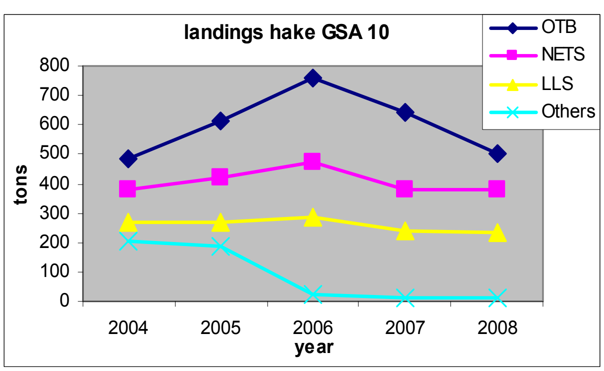
5.8.2.3.1. Landings

Available landing data are from DCF regulations. SGMED-10-02 received Italian landings data for GSA10 by fishing gears which are listed in Tab. 5.8.2.3.1.1.

Since 2004, landings of hake increased from 1,338 t to 1,544 t in 2006 and decreased to about 1,123 t in 2008 (Fig. 5.8.2.3.1.1). Most part of the landings of hake is from trawlers and nets (GNS and GTR), but the catches of the demersal longline fishery are also substantial.

Tab. 5.8.2.3.1.1. Annual landings (t) by major gear type, 2004-2008.

Somma di LW					YEAR				
AREA	SPECIES	FT_LVL3	FT_LVL4	FT_LVL5	2004	2005	2006	2007	2008
10	HKE	Bottom trawls	OTB	Deep water species			13.558	4.258	2.642
				Demersal species	186.179		97.004	172.701	350.532
				Mixed demersal and deep water species	299.705	611.932	648.723	463.741	147.429
		Longlines	LLD	Large pelagic fish		0.518			1.535
			LLS	Demersal fish	266.362	269.229	287.722	240.192	232.314
		Miscellaneous	Miscellaneous	"	197.794	177.08	8.319		
		Nets	GND	Small pelagic fish	6.595	8.038	11.976	10.643	8.074
			GNS	Demersal species	177.196	293.787	322.681	212.831	310.972
				Small and large pelagic fish				6.992	0.292
			GTR	Demersal species	202.169	124.151	152.068	157.296	67.622
		Seines	SB-SV	Demersal species	1.301				1.424
		Surrounding nets	PS	Small pelagic fish	1.266		2.012		
Total					1338.567	1484.735	1544.063	1268.654	1122.836



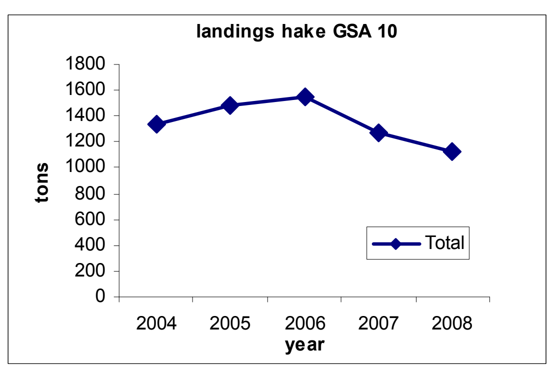


Fig. 5.8.2.3.1.1 Landings (t) by year and major gear types, 2004-2008 as reported through DCF in GSA 10.

5.8.2.3.2. *Discards*

The discards of hake in the GSA 10 are assessed to be low. About 16 tons of discards in 2006 were reported to SGMED-10-02.

5.8.2.3.3. *Fishing effort*

The trends in fishing effort by year and major gear type is listed in Tab. 5.8.2.3.3.1 in terms of kWdays.

Tab. 5.8.2.3.3.1 Trend in fishing effort (kW*days) for GSA 10 by gear type and vessel length, 2004-2008.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
10	ITA				VL0006				1347			
10	ITA				VL0612		84318	65385	32480	27509	24608	
10	ITA				VL1218		13612	27229	5986	18865	7513	
10	ITA	DRB	MOL		VL1218		10149	14848	23073	34394	21067	
10	ITA	FPO	DEMSP		VL0006				5938			
10	ITA	FPO	DEMSP		VL0612			14239				
10	ITA	GND	SPF		VL0006					1521	1437	
10	ITA	GND	SPF		VL0612			4316	8070		15882	
10	ITA	GND	SPF		VL1218		1895	3429			8303	
10	ITA	GNS	DEMSP		VL0006				221	9122	6623	
10	ITA	GNS	DEMSP		VL0612		45875	229661	74360	139622	124448	
10	ITA	GNS	DEMSP		VL1218						18180	
10	ITA	GTR	DEMSP		VL0006				30332	16894	13248	
10	ITA	GTR	DEMSP		VL0612		86781	82711	191382	140832	172542	
10	ITA	GTR	DEMSP		VL1218		12514	21108	28430	16110	17755	
10	ITA	LHP-LHM	CEP		VL0006				2369	3463	1018	
10	ITA	LHP-LHM	CEP		VL0612		1239	2450	4458	15003		
10	ITA	LHP-LHM	FINF		VL1218		716	1013				
10	ITA	LLD	LPF		VL0006						1968	
10	ITA	LLD	LPF		VL0612						2138	
10	ITA	LLD	LPF		VL1218		4627		10673	10266	14174	
10	ITA	LLS	DEMF		VL0006				11628	3467	2996	
10	ITA	LLS	DEMF		VL0612		104125	101629	61456	56957	26693	
10	ITA	LLS	DEMF		VL1218		13376	27517	61348	52670	32330	
10	ITA	OTB	DEMSP		VL0612		16454					
10	ITA	OTB	DEMSP		VL1218		44743		102448	127832	98014	
10	ITA	OTB	DEMSP		VL1824		90104		224283	204068	242063	
10	ITA	OTB	DWSP		VL1824						2388	
10	ITA	OTB	MDDWSP		VL1218		130612	247796	142430	169560	83026	
10	ITA	OTB	MDDWSP		VL1824		97221	239878	71963	86844	55526	
10	ITA	PS	LPF		VL0612					5291		
10	ITA	PS	LPF		VL1218					4926		
10	ITA	PS	SPF		VL0006				7337			
10	ITA	PS	SPF		VL0612		4653	27986				
10	ITA	PS	SPF		VL1218		49995	54113	68805	73452	20179	
10	ITA	SB-SV	DEMSP		VL0006				0			
10	ITA	SB-SV	DEMSP		VL0612		12786					
10	ITA	SB-SV	DEMSP		VL1218						8756	

5.8.3. Scientific surveys

5.8.3.1. Medits

5.8.3.1.1. Methods

According to the MEDITS protocol (Bertrand *et al*., 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish per surface unit) were standardized to square kilometer, using the swept area method.

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls was reported per depth stratum (Tab. 5.8.3.1.1.1).

Tab. 5.8.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	9	10	10	10	10	10	10	10	9	9	9	9	9	9	9	9
GSA10_050-100	12	12	12	12	12	12	12	12	10	10	10	10	10	10	10	10
GSA10_100-200	20	20	20	20	20	20	20	20	17	17	17	17	17	17	17	17
GSA10_200-500	26	27	26	26	27	26	26	28	22	22	22	22	22	22	22	22
GSA10_500-800	31	30	31	31	31	30	31	29	26	27	26	26	26	26	26	26

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*. 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.8.3.1.2. Geographical distribution patterns

The geographical distribution pattern of European hake has been studied in the area using trawl-survey data and applying geostatistical methods. In these studies both the total abundance indices (Lembo et al., 1998a) and the abundance indices of recruits were analysed (Lembo *et al*., 1998b, 2000b). The higher concentration of recruits in the GSA 10 were localised in the northern side (Gulfs of Napoli and Gaeta). Recent estimations have confirmed the presence of important zone for recruits in the northernmost part of the GSA, although sites with a high probability of locating a nursery appeared also along the coasts of southern part of the mainland and North Sicily. From GRUND data (autumn survey) the higher abundance of recruits were instead localised in the central part of the GSA, along the mainland coasts. Persistence of the nursery areas along the time was estimated from the indicator kriging (SGMED 09-02).

5.8.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 10 was derived from the international survey MEDITS. Figure 5.8.3.1.3.1 displays the estimated trend of hake abundance and biomass indices standardized to the surface unit in the GSA 10. Indices from MEDITS trawl-surveys show an increasing pattern in the last years, although variability is high (Fig. 5.8.3.1.3.1).

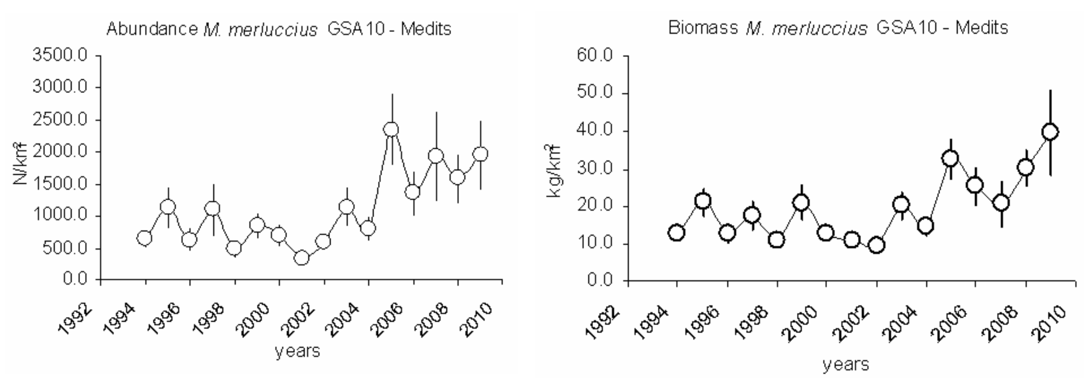


Fig. 5.8.3.1.3.1 Trends in survey abundance and biomass derived from MEDITS (bars indicate standard deviation).

The re-estimated abundance and biomass indices (Figure 5.8.3.1.3.2) also reveal increasing trends since 2002. However, the recent high abundance and biomass indices are subject to high uncertainty.

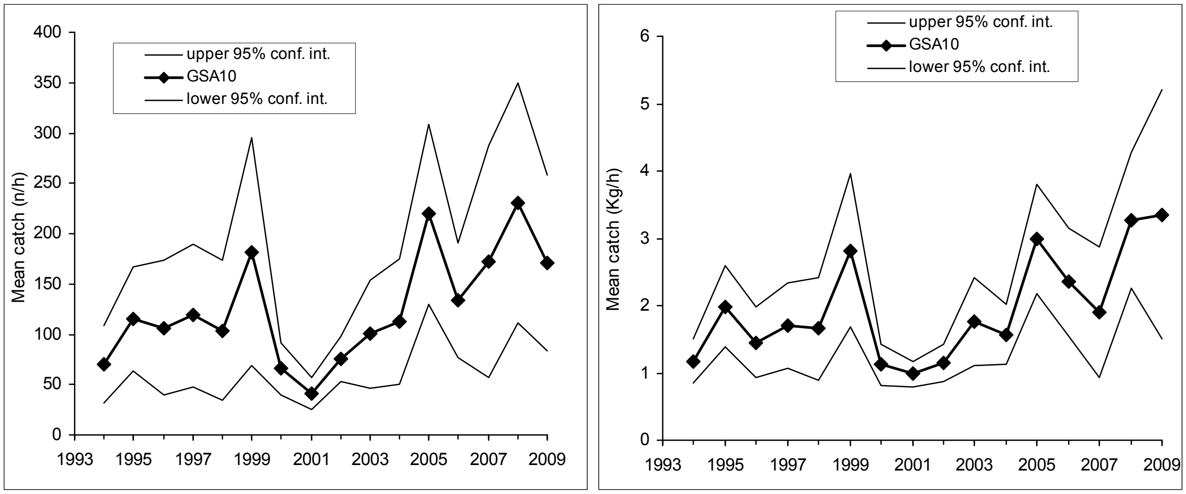
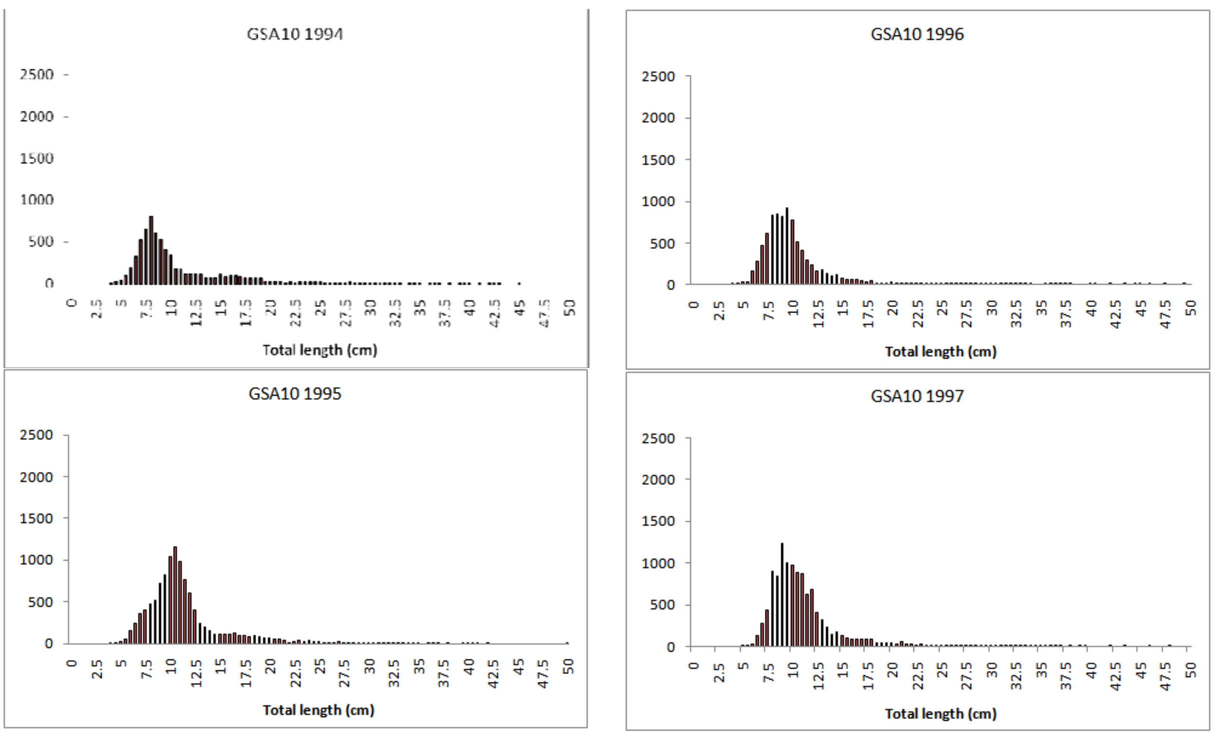


Fig. 5.8.3.1.3.2 Abundance and biomass indices of hake in GSA 10.

5.8.3.1.4. Trends in abundance by length or age

Fig. 5.8.3.1.4.1 and 2 illustrate the length compositions observed in 1994-2001 and 2002-2009, respectively.



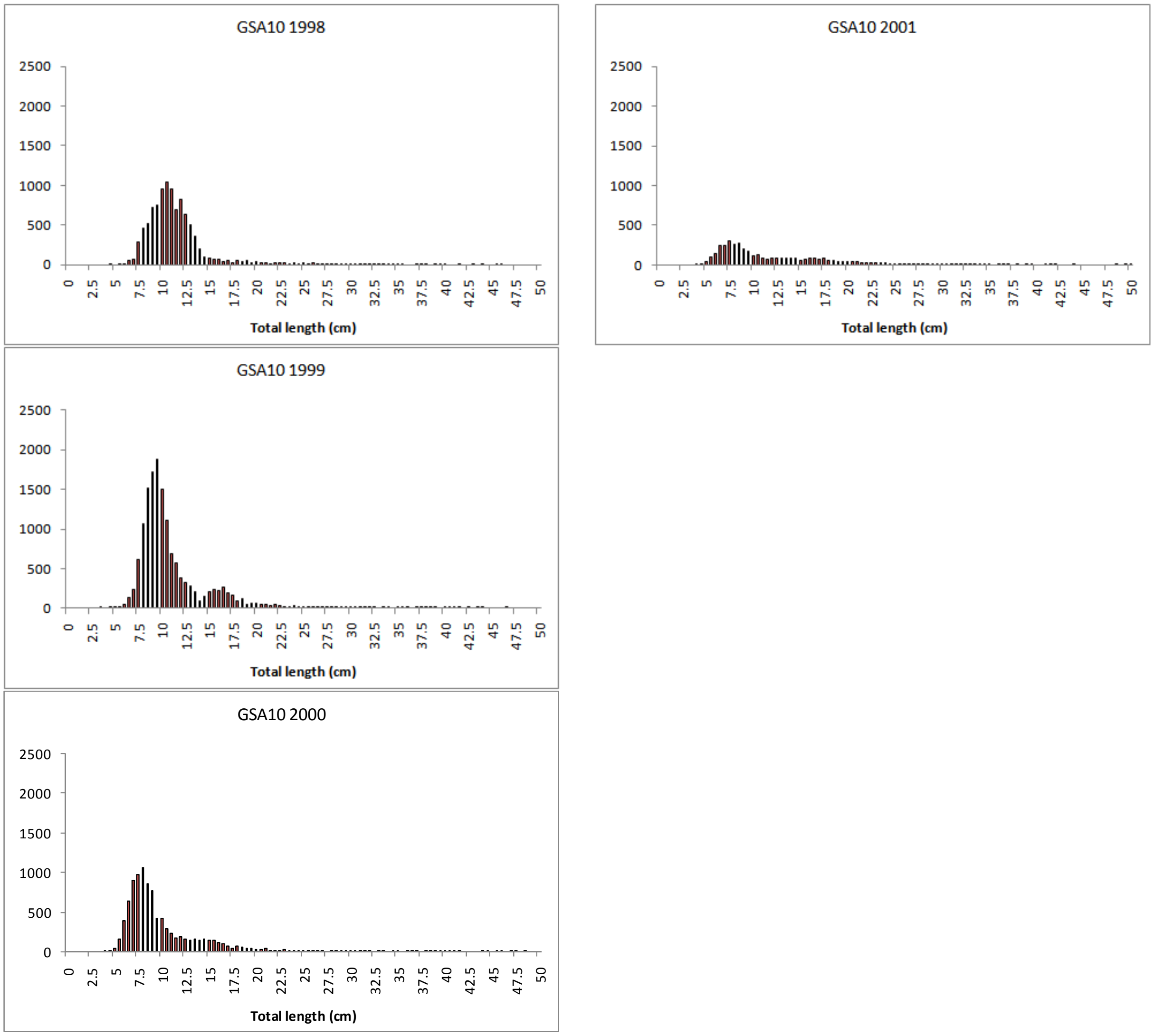
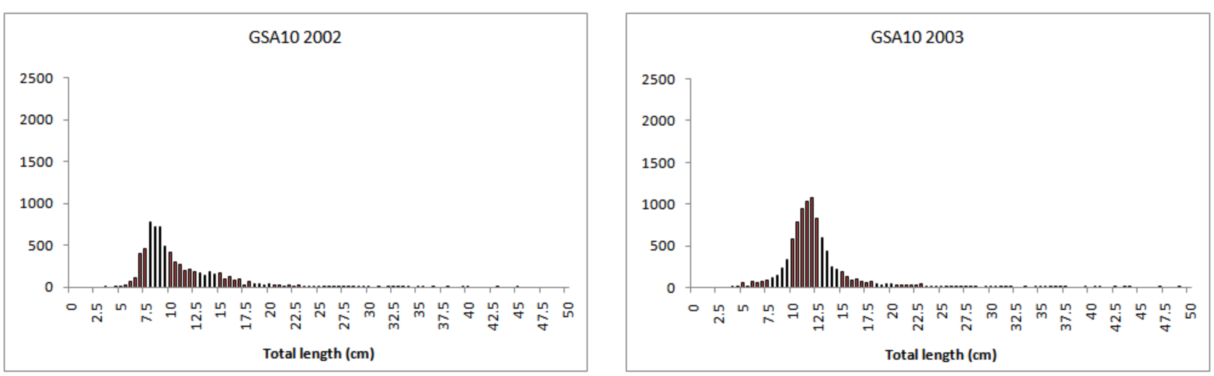


Fig. 5.8.3.1.4.1 Stratified abundance indices by size, 1994-2001.



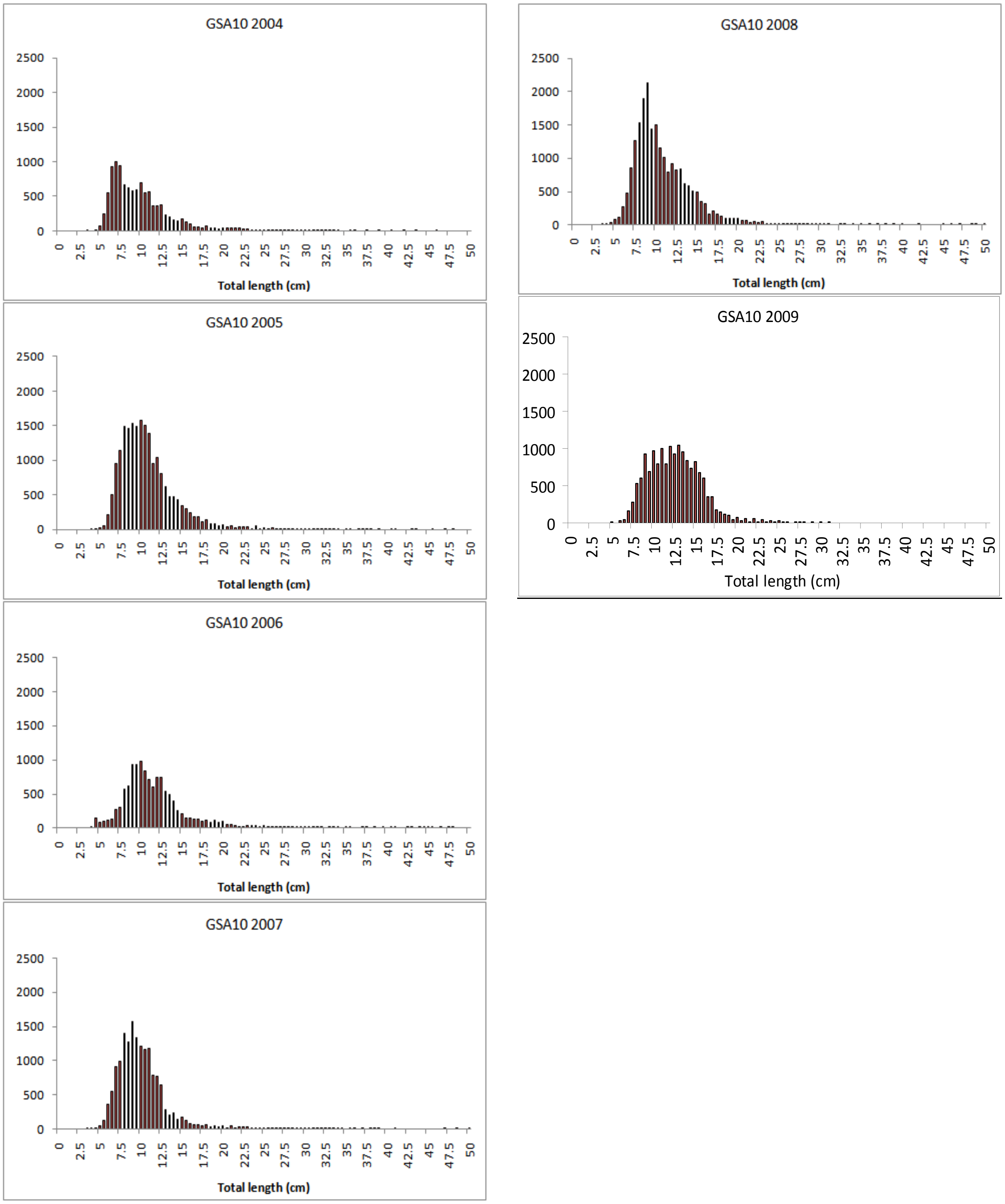


Fig. 5.8.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.8.3.2. GRUND

5.8.3.2.1. Methods

Since 2003 Grund surveys was conducted using the same vessel and gear in the whole GSA. Sampling scheme, stratification and protocols were similar as in MEDITS. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometer, using the swept area method.

5.8.3.2.2. Geographical distribution patterns

Mapping of the hake recruits obtained applying the indicator kriging technique with contouring that represents probability (in percentage) is reported in the STECF-SGMED 09-02 report.

5.8.3.2.3. Trends in abundance and biomass

Trends derived from the GRUND surveys are shown in Fig. 5.8.3.2.3.1. Abundance indices increased significantly ($p<0.05$ on ln-transformed data), as well as recruitment indices, while biomass indices were almost stationary.

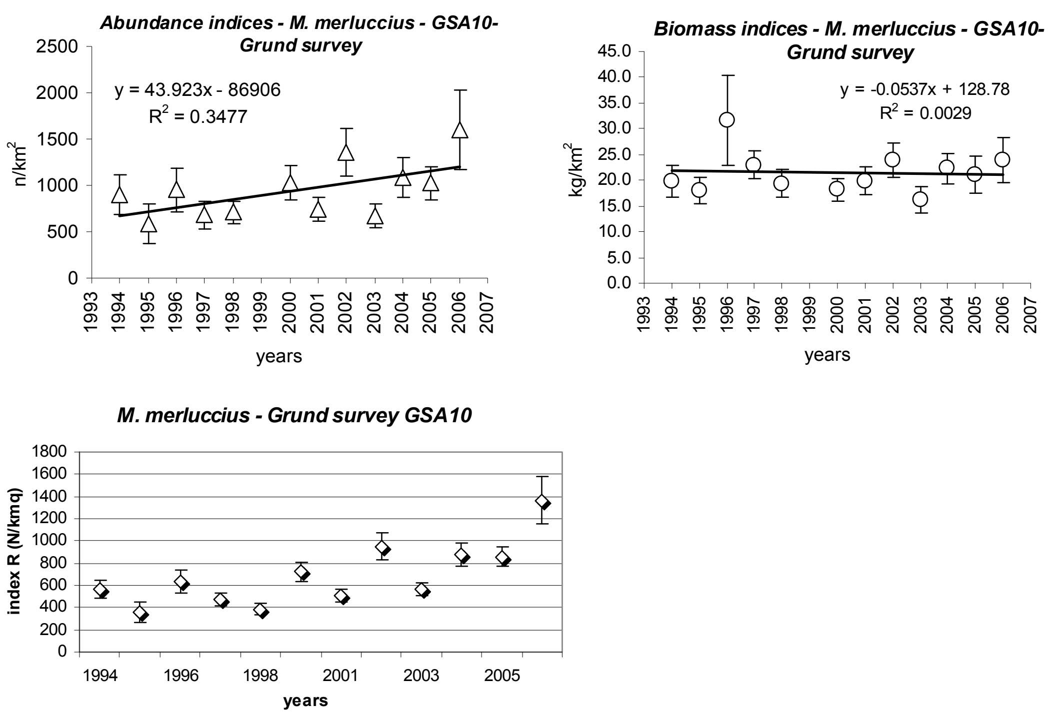


Fig. 5.8.3.2.3.1. Abundance and biomass indices of hake in GSA 10 derived from GRUND surveys. Recruitment indices (N/km^2) with standard deviation are also reported.

5.8.3.2.4. Trends in abundance by length or age

No trend in the mean length was observed in MEDITS survey (Fig. 5.8.3.2.4.1), nor at the third quantile lengths, as obtained from the length structures of GRUND time series from 1994 to 2006 (Fig. 5.8.3.2.4.2). However the mean length of older fish is reduced over the time.

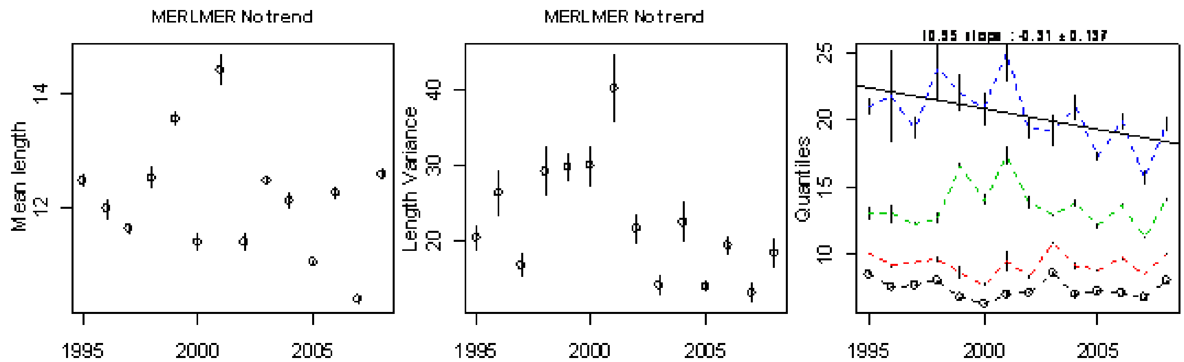


Fig. 5.8.3.2.4.1 Mean length, variance and quantiles derived from the MEDITS length compositions.

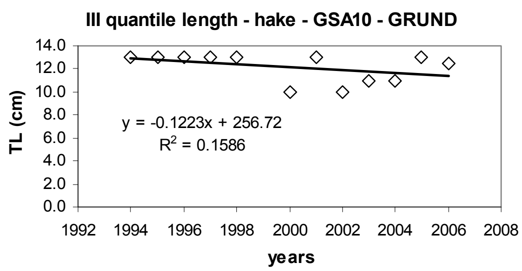


Fig. 5.8.3.2.4.2 III Quantile derived from the GRUND length structures in 1994-2006.

5.8.3.2.5. Trends in growth

No analyses were conducted.

5.8.3.2.6. Trends in maturity

No analyses were conducted.

5.8.4. Assessment of historic stock parameters

5.8.4.1. Method 1: Surba

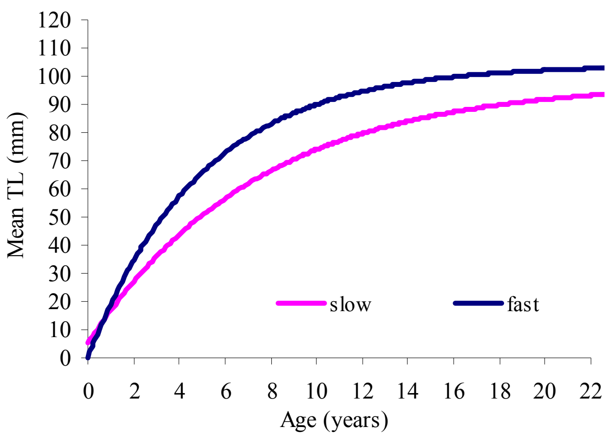
5.8.4.1.1. Justification

SURBA software was applied using MEDITS abundance estimates by length. Two scenarios based on a different growth pattern were used to account for uncertainty in the growth of the species.

5.8.4.1.2. Input parameters

Two sets of growth parameters were used in the analyses to split the LFDs, after that these were raised to the square km and averaged over the area for the SURBA analyses.
Set 1) ‘slow’ growth

Females: L_∞=97.9 cm, K=0.135, t_0= -0.4; Males: L_∞=50.8 cm, K=0.25, t_0= -0.4; length-weight relationship: a=0.00355, b=3.22 for sex combined.
<u>Set 2) 'fast' growth</u>
L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship: a=0.00355, b=3.22 for sex combined.
Length at age and graphs of the growth curves according to the two sets are reported in Fig. 5.8.4.1.2.1 and Tab. 5.8.4.1.2.1.



growth	slow	fast
age (years)	mean length (cm)	mean length (cm)
0	5.03	0.21
1	16.77	19.02
2	27.03	34.43
3	35.99	47.04
4	43.82	57.36
5	50.66	65.82
6	56.64	72.74
7	61.86	78.41
8	66.43	83.04
9	70.41	86.84
10	73.90	89.95

Fig. 5.8.4.1.2.1 Growth scenarios used in the assessment

The age groups derived from the age slicing performed using the LFDA software are reported in Tab. 5.8.4.1.2.1. Age slicing was conducted on separate sex in the case of 'slow' parameter set and numbers were afterward combined. A 5+ group and a 4+group were respectively used for the two data sets.

Tab. 5.8.4.1.2.1 Age groups obtained after the age slicing procedure and used as input in SURBA.

	'Slow' age groups						'fast' age groups				
Year	0	1	2	3	4	5+	0	1	2	3	4+
1994	539.4	91.35	15.92	4.52	0.7	0.73	600.1	48.7	3.411	0.2	0.2
1995	916.6	173.2	24.19	3.01	0.9	0.87	1018	97.56	2.465	0.14	0.24
1996	527.6	82	14.37	3.66	1.78	0.48	578.1	48.42	3.008	0.42	0
1997	962.6	117.2	13.63	2.77	0.5	0.24	1037	57.45	1.96	0.24	0
1998	392.9	64.03	17.94	2.49	1.11	0.47	421.6	54.7	2.517	0	0.15
1999	522.4	291.6	20.93	5.31	0.96	0.86	743.9	94.89	3.225	0.12	0
2000	671.7	113.2	13.96	4.15	1.49	0.39	746	54.43	3.809	0.603	0.038
2001	210.1	93.95	15.61	2.12	1.1	0.61	259.1	61.23	2.563	0.47	0.11
2002	481.2	89.02	9.68	1.65	0.77	0.17	544.6	36.29	1.4	0	0
2003	1002	118.5	16.97	3.84	0.86	0.28	1075	63.39	3.141	0.399	0
2004	667.9	107.9	12.52	2.9	0.27	0.58	732.7	57.54	1.306	0	0.41
2005	2109	216.8	26.04	2.58	1.09	0.81	2267	86.38	2.209	0.607	0.23
2006	1134	188.9	25.69	2.82	1.3	0.17	1250	100.1	2.323	0.51	0
2007	1812	92.19	14.81	1.41	0.76	0.83	1869	50.69	1.188	0.973	0.28
2008	1378	239.1	18.84	3.81	1.33	1.46	1544	93.24	2.936	1.498	0.39
2009	1560	388.5	20.14	1.2	0.17	0.67	1891	78.38	0.38	0.32	0.32

The other settings of the model, regarding natural mortality, catchability, maturity and weight at age, are reported in Tab. 5.8.4.1.2.2. Natural mortality vector for the two scenarios were obtained applying the Prodbiom method (Abella *et al*., 1997) and calculation sheet was provided by the author.

Tab. 5.8.4.1.2.2 SURBA settings related to the natural mortality (M), the catchability coefficient q, the proportion of mature and the weight at age in the slow and fast growth scenarios.

Age	0	1	2	3	4	5+
M (slow)	0.85	0.46	0.37	0.33	0.31	0.29
M (fast)	1.16	0.53	0.40	0.35	0.318	
q (slow)	0.9	1	1	0.75	0.5	0.5
q (fast)	0.9	1	1	0.75	0.5	
Proportion mature (slow)	0.00181	0.311	0.968	1	1	1
Proportion mature (fast)	0.0082	0.248	0.887	1	1	
Weight (kg) (slow)	0.01	0.07	0.20	0.41	0.67	1.81
Weight (kg) (fast)	0.01	0.15	0.56	1.23	3.50	

The mean F range in SURBA was calculated over ages 1-3.

5.8.4.1.3. Results

Estimates of total mortality from SURBA, for sex combined and for slow and fast growth, are presented in Tab. 5.8.4.1.3.1.

Tab. 5.8.4.1.3.1 Relative estimates of total mortality Z and spawning stock biomass SSB from Surba, for sex combined and for slow and fast growth scenarios.

	Slow growth pattern - Results				Fast growth pattern - Results			
	Original		Smoothed		Original		Smoothed	
Year	SSB	Z	SSB	Z	SSB	Z	SSB	Z
1994	0.896	1.536	0.929	1.506	0.896	1.536	0.929	1.506
1995	1.221	1.634	1.055	1.549	1.221	1.634	1.055	1.549
1996	0.836	1.81	0.935	1.588	0.836	1.81	0.935	1.588
1997	0.731	1.497	0.845	1.389	0.731	1.497	0.845	1.389
1998	0.769	1.096	0.998	1.427	0.769	1.096	0.998	1.427
1999	1.519	1.976	1.111	1.531	1.519	1.976	1.111	1.531
2000	0.882	1.731	0.959	1.692	0.882	1.731	0.959	1.692
2001	0.8	1.844	0.805	1.628	0.8	1.844	0.805	1.628
2002	0.547	1.078	0.646	1.372	0.547	1.078	0.646	1.372
2003	0.877	2.223	0.775	1.46	0.877	2.223	0.775	1.46
2004	0.74	1.327	0.907	1.573	0.74	1.327	0.907	1.573
2005	1.341	1.68	1.022	1.482	1.341	1.68	1.022	1.482
2006	1.175	2.253	1.201	1.665	1.175	2.253	1.201	1.665
2007	0.77	1.001	1.108	1.854	0.77	1.001	1.108	1.854
2008	1.435	2.779	1.188	2.367	1.435	2.779	1.188	2.367
2009	1.46	NA	1.515	NA	1.46	NA	1.515	NA

In the slow growth hypothesis, the temporal trend of F and the mean F estimates in the age range 1-3 years showed an increasing pattern and a high variability as well as the estimates of SSB index. The retrospective analysis showed a sharp increase of recruitment. Residuals varied without any trend.

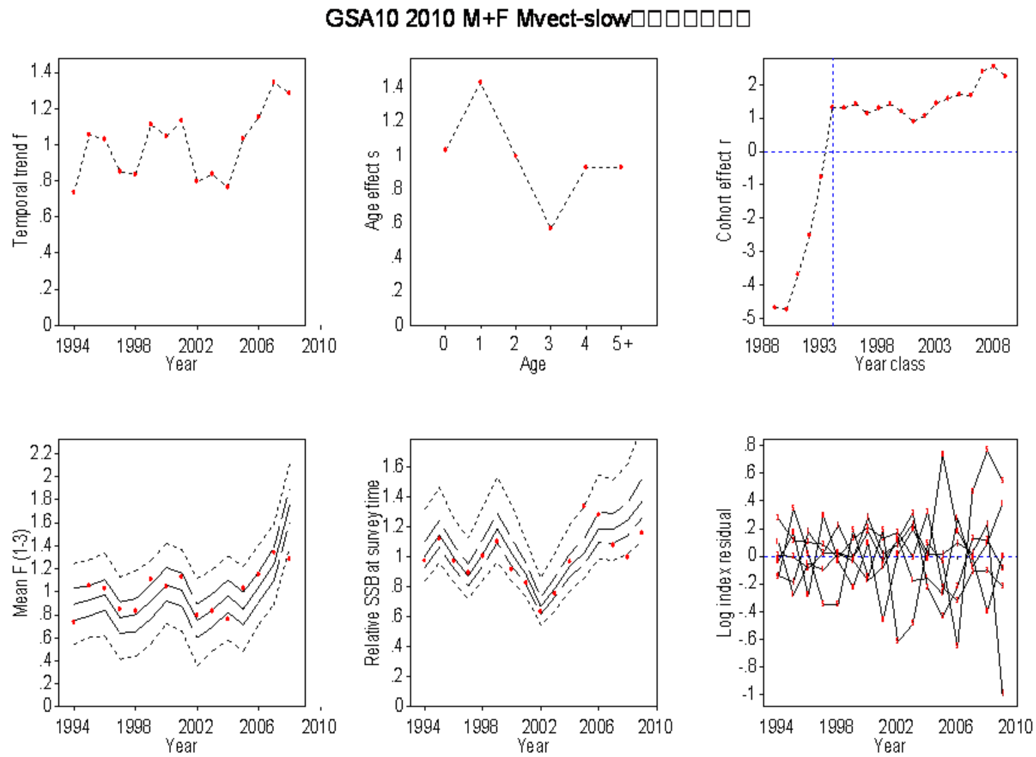


Fig. 5.8.4.1.3.1 Trends in various stock parameters from SURBA, hake GSA 10, slow growth pattern.

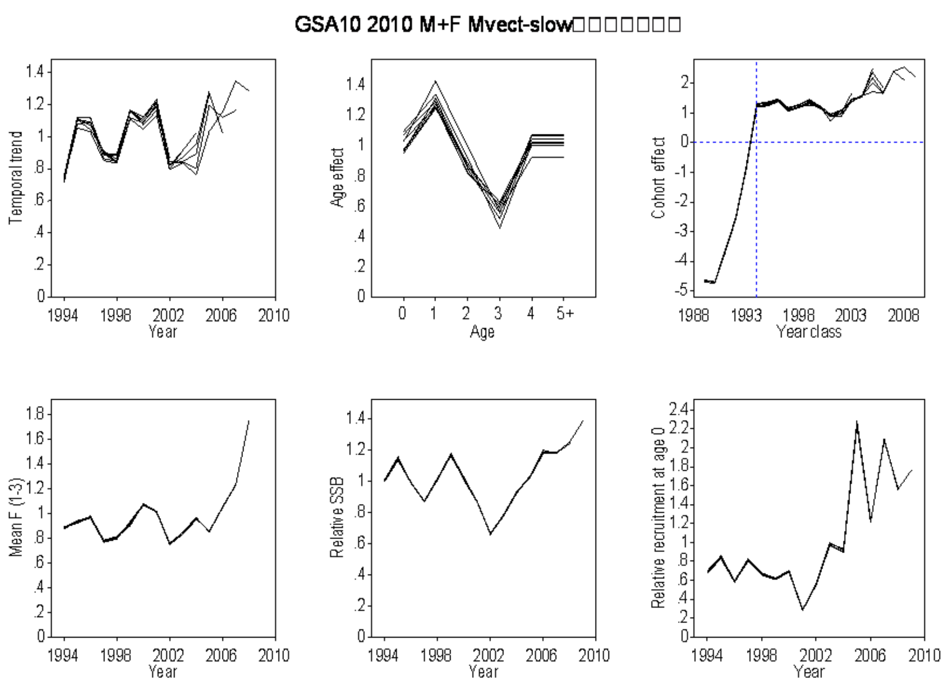


Fig. 5.8.4.1.3.2 Retrospective analysis from SURBA, hake GSA 10, slow growth pattern.

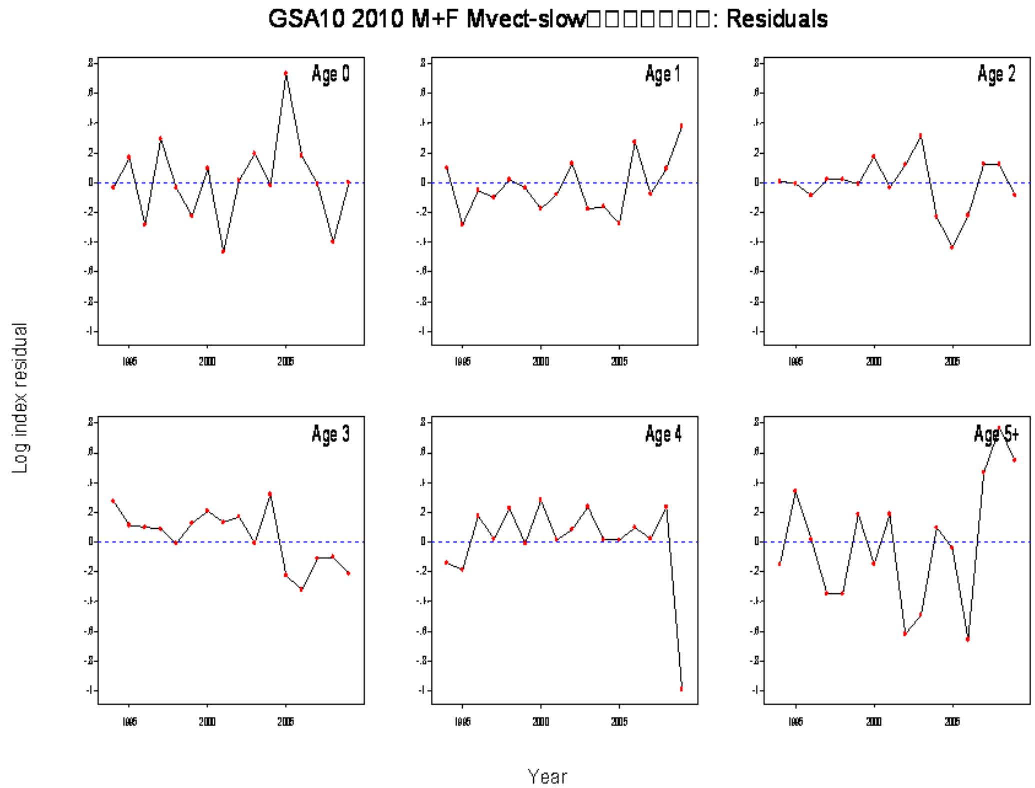


Fig. 5.8.4.1.3.3 Residuals from SURBA, hake GSA 10, slow growth pattern.

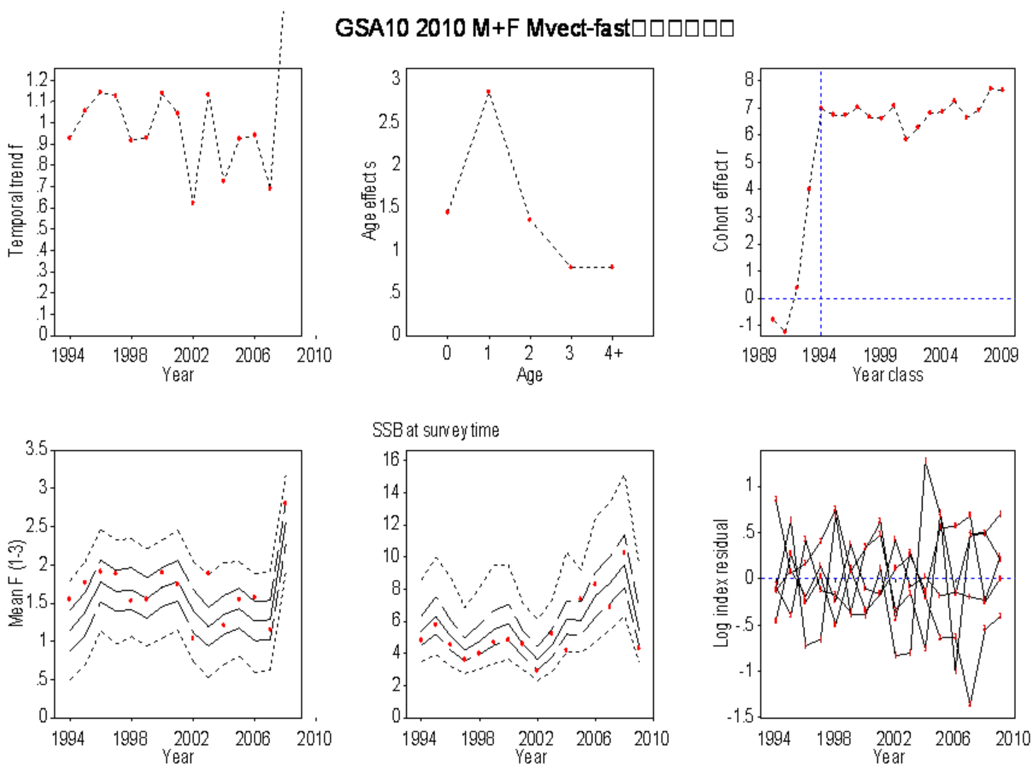


Fig. 5.8.4.1.3.4 Trends in various stock parameters from SURBA, hake GSA 10, fast growth pattern.

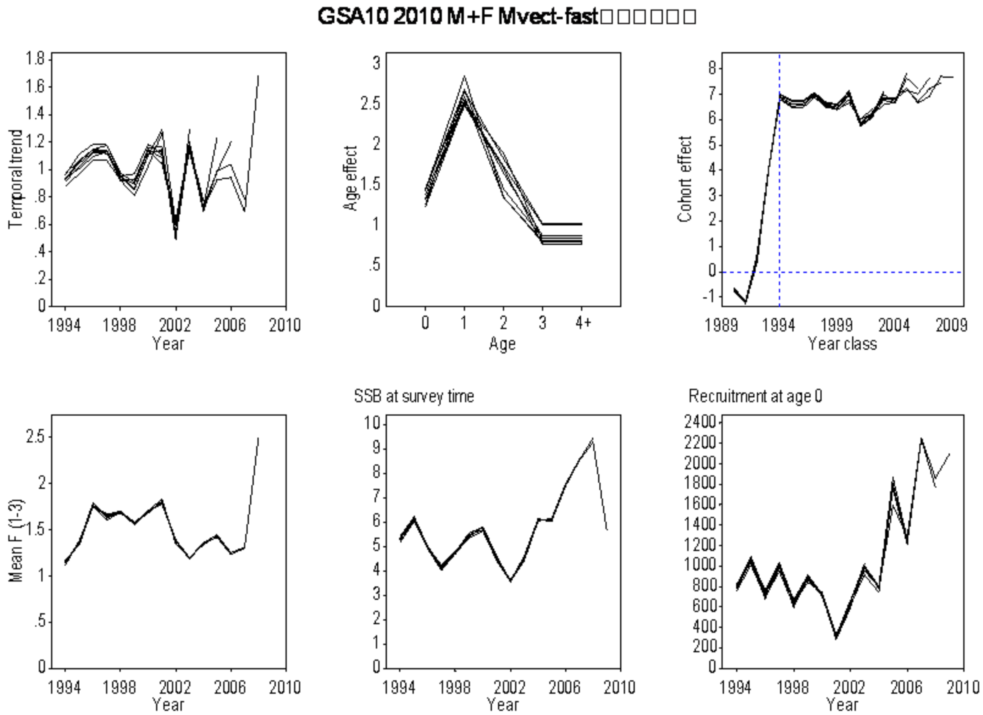


Fig. 5.8.4.1.3.5 Retrospective analysis from SURBA, hake GSA 10, fast growth pattern.

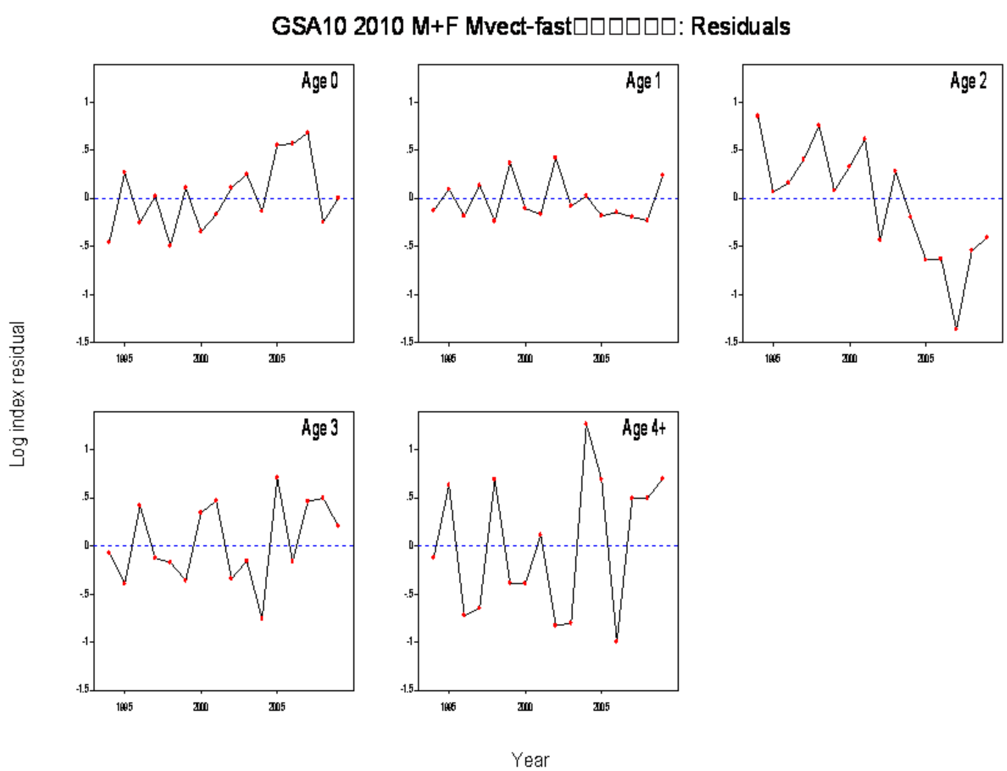


Fig. 5.8.4.1.3.6 Residuals from SURBA, hake GSA 10, fast growth pattern.

In the fast growth hypothesis, the temporal trend of F and the mean F estimates in the age range 1-3 showed a remarkable increasing pattern and a high variability as well as the SSB index estimates that showed a decrease since 2006. The analysis showed also a sharp increase of recruitment. Residuals varied without any trend, except for age 2.

The overall (for the whole life span) fishing mortality rate has been calculated as geometric mean for the slow and fast growth pattern and is reported in the Fig. 5.8.4.1.3.7. In 2006 average F was 1.2 for both the scenarios. In 2007 it was 0.767 and 0.889 for the slow and fast growth scenario respectively, while in 2008 it was 1.33 and 2.16, respectively.

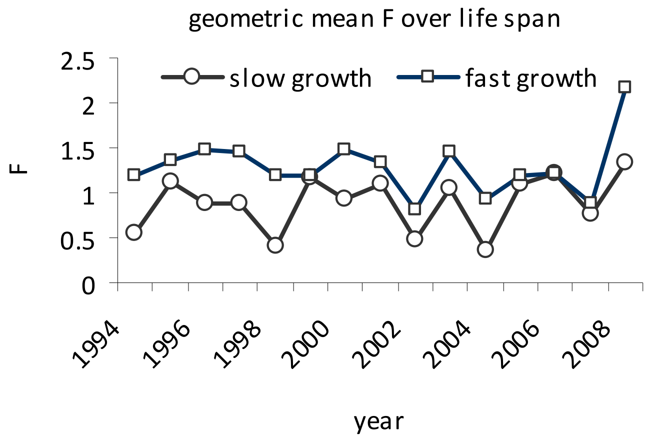


Fig. 5.8.4.1.3.7 Geometric mean of F from SURBA calculated over the life span for the fast and slow growth pattern of hake in the GSA 10.

5.8.4.2. Method 2: VIT

5.8.4.2.1. Justification

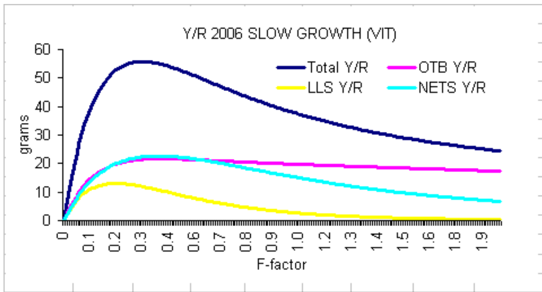
The cohort analysis and the Y/R approach as implemented in the VIT software under equilibrium conditions were used, as the time series of landings is short.

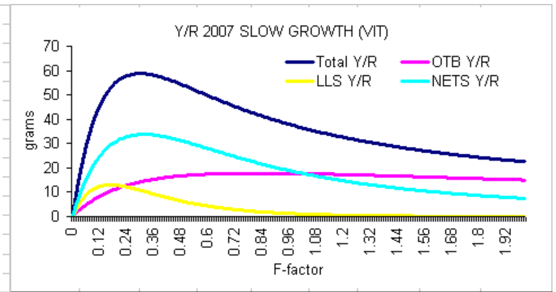
5.8.4.2.2. Input parameters

The input parameters regarding age, maturity, natural mortality and length-weight relationship were those already reported for the SURBA inputs. The landing structures (in length and age) of 2006, 2007 and 2008 were from the SGMED 2010 data call. The terminal fishing mortality F_{term} was set in the model equal to 0.32. Also in this case the same 2 growth scenarios slow and fast, as in SURBA data sets were used.

5.8.4.2.3. Results

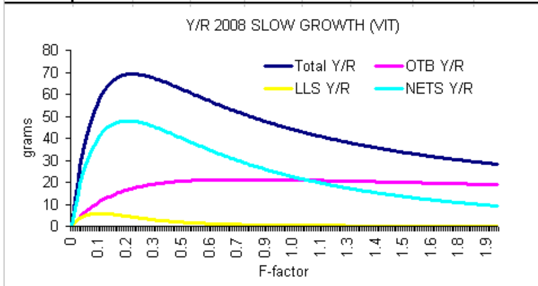
The Y/R analyses from VIT by gear for the slow growth pattern are reported in Fig. 5.8.4.2.3.1 while those related to the Z and F cohort analysis are reported in Fig. 5.8.4.2.3.2. The Figure 5.8.4.2.3.3. shows the Y/R analyses under the slow growth scenario and the Fig. 5.8.4.2.3.4. represents the comparison of the two scenarios and summarize the main findings.





2006	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	750.03	720.2	0	0	0
F(0.1)	0.26	0.1617	53.862	311.7	286.7	20.281	13.008	20.573
Fmax	0.37	0.2301	55.792	231.88	208.5	21.473	11.952	22.368
Fcurr	1.01	0.622	39.124	57.737	41.27	19.953	3.13	16.041
Fdouble	2	1.244	24.403	20.199	9.192	17.317	0.358	6.728

2007	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	885.35	855.5	0	0	0
F(0.1)	0.22	0.1441	56.979	337.05	311.7	12.288	12.517	32.175
Fmax	0.31	0.2031	58.802	250.44	226.5	14.299	10.757	33.746
Fcurr	1.01	0.655	36.834	48.166	32.38	17.68	1.105	18.048
Fdouble	2	1.31	22.546	17.779	7.533	15.017	0.058	7.47



2008	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	885.35	855.5	0	0	0
F(0.1)	0.2	0.1602	66.502	408.17	381.5	14.431	5.382	46.689
Fmax	0.3	0.2403	69.204	310.32	284.9	17.303	4.144	47.756
Fcurr	1.01	0.801	45.014	75.613	57.41	21.086	0.457	23.472
Fdouble	2	1.602	28.194	27.102	14.45	18.897	0.087	9.209

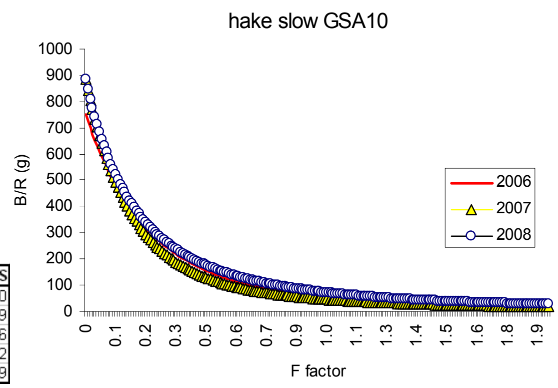


Fig. 5.8.4.2.3.1 Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported. B/R by year and F-factor is also showed (right, down side). Slow growth scenario.

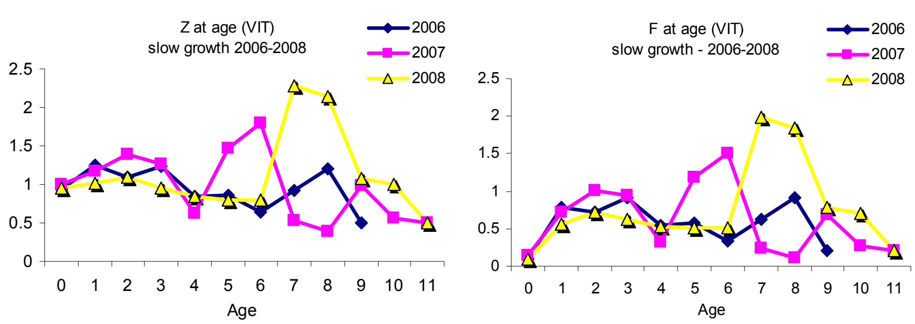
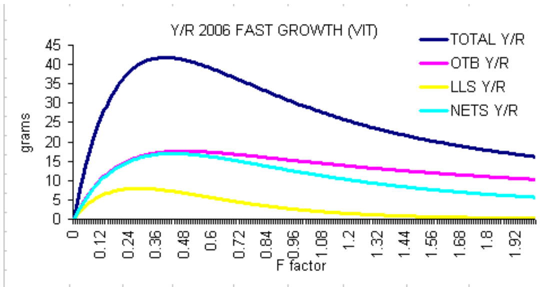
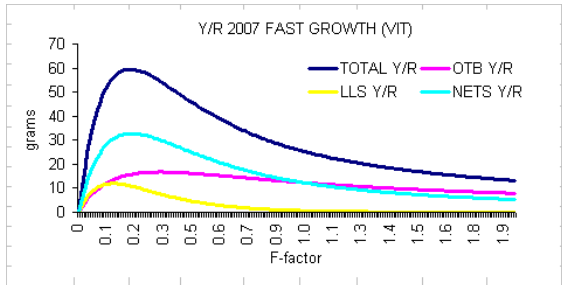


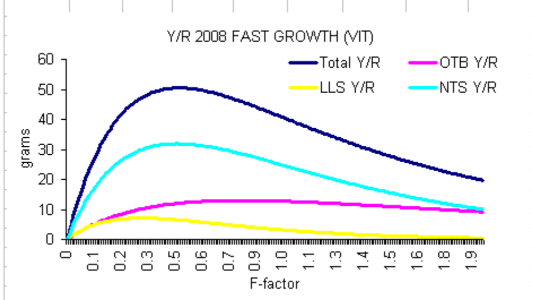
Fig. 5.8.4.2.3.2 Total and fishing mortality by age as estimated by the cohort analysis using VIT, by year. Slow growth scenario.



2006	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	543.76	499.58	0	0	0
F(0.1)	0.31	0.225	40.832	191.79	163.76	16.602	7.96	16.269
Fmax	0.41	0.297	41.789	144.25	119.38	17.416	7.45	16.922
Fcurr	1.01	0.725	29.219	29.18	16.42	14.902	2.338	11.98
Fdouble	2	1.45	16.191	7.48	1.34	10.293	0.227	5.671

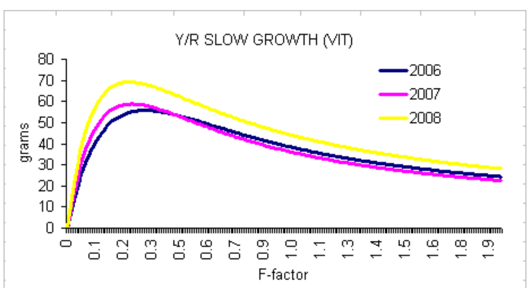


2007	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	697.94	653.76	0	0	0
F(0.1)	0.18	0.199	57.736	267.65	235.32	14.301	11.857	31.577
Fmax	0.25	0.277	59.422	200.36	171.03	15.79	10.908	32.724
Fcurr	1.01	1.107	26.12	18.349	7.439	12.538	0.784	12.799
Fdouble	2	2.214	13.217	5.586	0.735	7.889	0.026	5.302

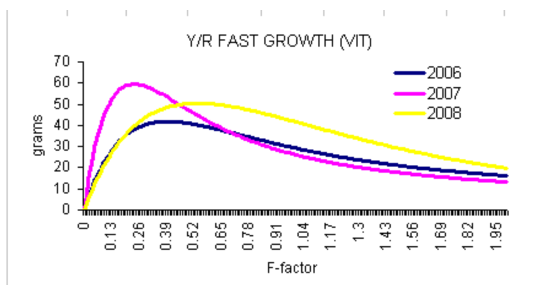


2008	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	697.94	653.76	0	0	0
F(0.1)	0.42	0.182	49.198	290.24	260.33	10.997	7.033	31.168
Fmax	0.55	0.239	50.464	228.86	202.02	12.101	6.48	31.883
Fcurr	1.01	0.434	41.685	97.505	79.599	12.821	3.397	25.467
Fdouble	2	0.868	19.702	21.04	13.12	9.197	0.504	10.002

Fig. 5.8.4.2.3.3 Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported. Fast growth scenario.



Year	Fcurr	Y/R	Fcurr 1-3	F0.1	Y/R	Fmax	Y/R	Z
2006	0.622	39.124	0.812	0.162	53.862	0.2301	55.792	0.999
2007	0.655	36.834	0.892	0.144	56.979	0.2031	58.802	1.017
2008	0.801	45.014	0.636	0.160	66.502	0.2403	69.204	1.163



YEAR	Fcurr	Y/R	Fcurr 1-3	F0.1	Y/R	Fmax	Y/R	Z
2006	0.725	29.219	1.121	0.2248	40.832	0.2973	41.789	1.234
2007	1.107	26.12	1.43167	0.1993	57.736	0.2768	59.422	1.584
2008	0.434	41.685	0.47	0.1823	49.198	0.2387	50.464	0.91

Fig. 5.8.4.2.3.4 Comparison of overall Y/R curves for the two scenarios.

The results for the slow growth scenario show an increasing level of the current fishing mortality that change from 0.622 in 2006 to 0.801 in 2008. This increasing pattern is in agreement with that estimated from SURBA, although the values of the F estimated from VIT are considerably lower than those estimated by SURBA. In the fast growth scenario the estimates of F, Y/R, $F_{0.1}$, F_{max}, and Z are consistent with an accelerated dynamics maintaining a similar yearly pattern as in the slow growth scenario, except for 2008, that shows an anomalous behaviour.

5.8.5. Data quality and availability

Fishery dependent data for 2009 was not submitted by the Italian authorities. Due to lack of numbers-at-age or numbers-at-length from the landings, the update of the VIT assessment in 2009 was therefore not carried out. Analysis of the effort data were not updated as submitted data appear not consistent with previous estimates for the GSA. The time series from trawl survey was complete. A check of hauls allocation between GSA 09 and 10 needs to be done before calculation of indices from JRC MEDITS database. Data on maturity and growth have also been used. Information from GRUND surveys and from nurseries studies in the GSA have also been included.

5.8.6. Long term prediction

5.8.6.1. Justification

A yield per recruit analyses was conducted using the VIT software.

5.8.6.2. Input parameters

Like used in the Surba and VIT assessments described above.

5.8.6.3. Results

See VIT assessments in the sections above.

5.8.7. Scientific advice

5.8.7.1. Short term considerations

5.8.7.1.1. State of the spawning stock size

Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. However, recent values are among the highest observed since 1994. The hind casting approach using Aladym model in SGMED-09-02 in 2009 showed instead that the SSB was continuously decreasing (Fig. 5.8.7.1.1.1).

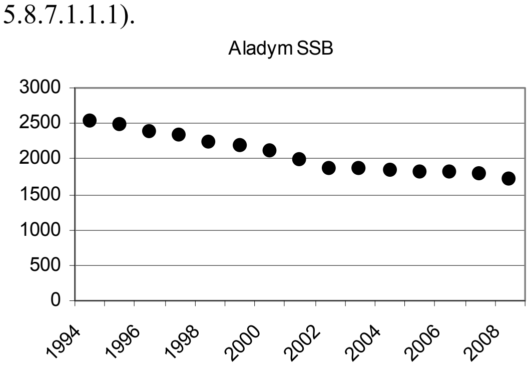


Fig. 5.8.7.1.1.1 Pattern of the spawning stock biomass as obtained through Aladym simulation in SGMED 09-02.

No biomass reference points have been proposed for this stock. As a result, SGMED is unable to evaluate the status of the stock with respect to biomass.

5.8.7.1.2. State of recruitment

Recent recruitment since 2006 appears to be above average, as derived directily from the trawl survey estimates considering as recruits the age 0 group (Fig. 5.8.7.1.2.1) and from the SURBA model analysis.

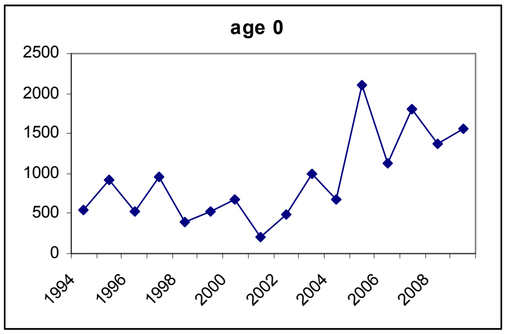


Fig. 5.8.7.1.2.1 Recruitment pattern from survey data.

5.8.7.1.3. State of exploitation

Given the results of the present analysis, the stock appeared to be overexploited in 2006-2008. Regardless of the growth pattern a considerable reduction is necessary to approach the $F_{0.1}$ reference point (Factor; ~70-80% of the current F value, depending on the year) which can be considered in the range 0.16-0.20.

5.9. Stock assessment of hake in GSA 11

5.9.1.Stock identification and biological features

5.9.1.1. Stock Identification

This stock is assumed to be confined within the GSA 11 boundaries, where it is distributed between 30 and 650 m of depth, with a peak in abundance (due to high number of recruits) over the continental shelf-break (between 150 and 250 m depth). The stock is mainly exploited by the local fishing fleet, although seasonally and occasionally some other Italian fleet use to fish in some areas of the GSA 11. Spawning is taking place almost all year round, with a peak during winter –spring.

Juveniles showed a patchy distribution with some main density hot spots (nurseries) showing a high spatio-temporal persistence (Murenu *et al*., 2007) in western areas.

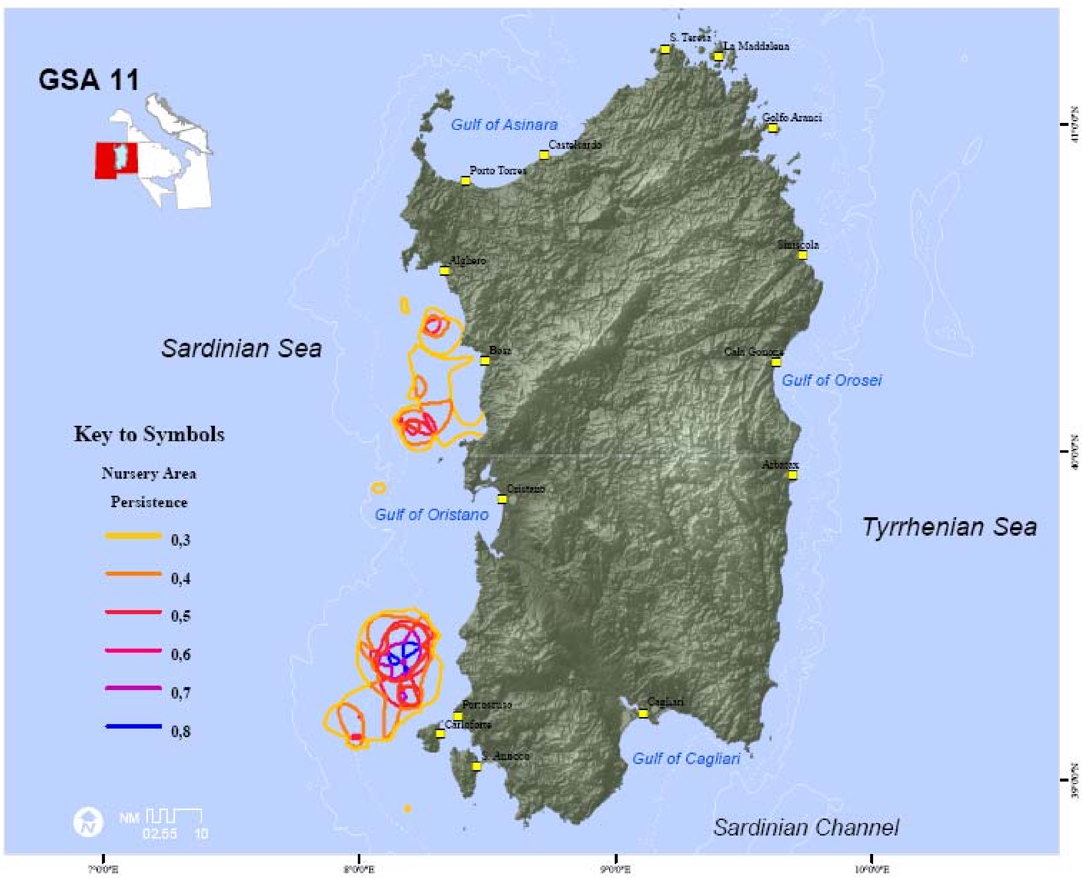


Fig. 5.9.1.1.1 Temporal persistence of hake nurseries calculated from data survey time-series density maps (1994-2006) of juveniles.

5.9.1.2. Growth

Analysis of LFDA of hake in GSA 11 showed a slow growth pattern both in male and female (SAMED, 2002). A slower growth pattern for the GSA 11 hake population comes also from otolith readings. New Von Bertalanffy Growth Function parameters have been calculated and used in this assessment. This is in line with recent evidences that suggest a fast growing pattern hypothesis for hake either in the Western Mediterranean (Garcia-Rodriguez and Esteban, 2002; Jadaud *et al*., 2006; Piñeiro *et al*., 2007) or in the Bay of Biscay (De Pontual *et al*., 2003).

5.9.1.3. Maturity

Due to the low catchability of large hake in trawl, the catch rate of mature specimens during the MEDITS trawl survey is usually very low, influencing the identification of gonad development and growth rate for large individuals. Female length at first maturity is estimated at around 36 cm. Although spawning around Sardinian coasts (GSA 11) occurs nearly all over the year (January to September), a maturity peak is usually observed in winter and spring (February-May).

5.9.2. Fisheries

5.9.2.1. General description of fisheries

Hake is one of the most important commercial species in the Sardinian seas. In this area, the biology and population dynamics have been studied intensively in the past fifteen years. Although hake is not a target of a specific fishery, such as for example red shrimp, it is the third species in terms of biomass landed in GSA 11 (Murenu M., pers. com.). In the GSA 11 hake is caught exclusively by a mixed bottom trawl fishery at depth between 50 and 600 m. No gillnet or longline fleets target this species. Although different nets are used in shallow, mid and deep water ("terra" mainly targeting *Mullus* spp., "mezzo fondo" targeting fish and "fondale" net targeting deep shrimp) the main trawl used is an "Italian trawl net" type with a low vertical opening (max up to 1.5 m). The dimensions of the trawl change in relation to the trawlers engine power. Important by catch species are horned octopus, squids, poor cod, shortnose greeneye, greater forkbeard and pink shrimp.

Detailed maps of the fishing-grounds are reported in Murenu *et al*. (2006). Most of the effort is concentrated within a relative short distance around the major fishing ports (Cagliari, Alghero, Porto Torres, La Caletta, Sant'antioco, Oristano, Alghero). Moreover, some large trawlers move seasonally in different fishing grounds far from the usual ports.

From 1994 to 2004, the trawl fleet showed remarkable changes in GSA 11. Those mostly consisted of a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. For the entire GSA an increase of 85% for boats >70 tons class occurred. A decrease of 20% for the smaller boats (<30 GRT) was also observed.

5.9.2.2. Management regulations applicable in 2009 and 2010

As in other areas of the Mediterranean, the management of this stock is based on the control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06). Two small closed areas were also established along the mainland (west and east coast respectively) although these are defined to mainly protect Norway lobster. Since 1991, a fishing closure for 45 trawling days has been enforced (month and year are reported on the following figure) almost every year.

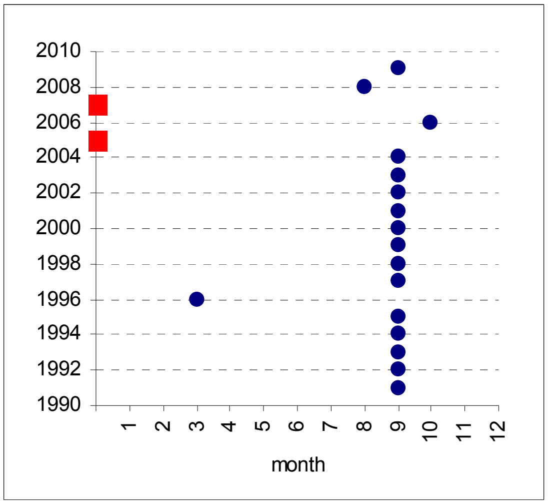


Fig. 5.9.2.2.1 Month and year of the fishing closure. Red points show the years when no closing measure was adopted.

Towed gears are not allowed within the three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

5.9.2.3. Catches

5.9.2.3.1. Landings

Landings data from 2009 were not submitted by the Italian authorities. Landings available for GSA 11 by major fishing gears are listed in Tab. 5.9.2.3.1.1. Since 2002, landings increased from 360 t to 930 t in 2005 and decreased to 340 t in 2008 (Fig. 5.9.2.3.1.1). Landings of hake are mostly taken by the demersal trawl fisheries (DTS, OTB and partially PMP). According to SGMED scientist's knowledge, official DCF data for GSA 11 is likely overestimating the contribution of the landings derived from LLS, GNS and GTR. A cross-check of the official data and the update of 2009 landings information is needed to improve and allow the assessment of hake in next SGMED meetings.

Tab. 5.9.2.3.1.1 Landings (t) by year and major gear types, 2002-2008 as reported through DCF in 2009.

FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DTS	167	592					
GNS			32	60	8	37	22
GTR			81	101	206	63	29
LLS			1	2	16	8	10
OTB			597	765	594	442	279
PGP	4	26					
PMP	190	279					
total landings (all gears)	361	897	711	928	824	550	340

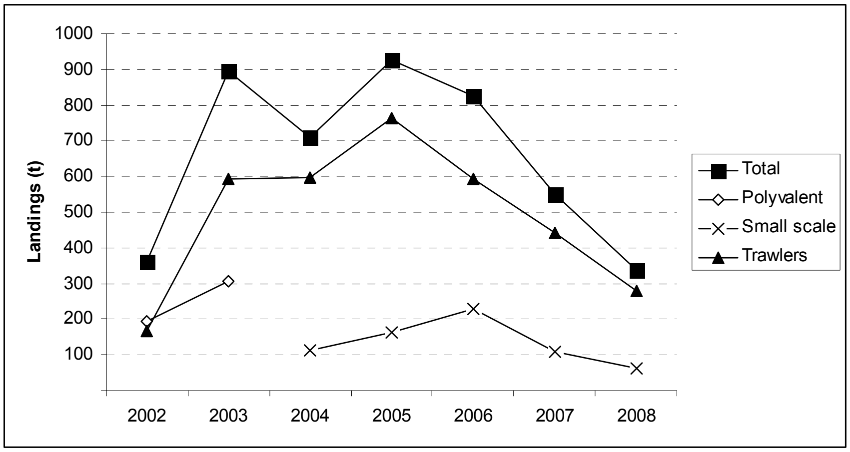


Fig. 5.9.2.3.1.1 Landings (t) by year and major gear types, 2002-2008 as reported through DCF.

Tab. 5.9.2.3.1.2 Landings (t) by year and major gear types, 2004-2008 as reported through DCF in 2010.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	11	ITA	GNS	DEMSP				32	60	8	37	22	
HKE	11	ITA	GTR	DEMSP				81	101	206	63	29	
HKE	11	ITA	LLD	LPF						3	0		
HKE	11	ITA	LLS	DEMF				1	2	13	8	10	
HKE	11	ITA	OTB	DEMSP				155	158	137	7	134	
HKE	11	ITA	OTB	DWSP								6	
HKE	11	ITA	OTB	MDDWSP				442	607	456	435	139	
Sum								711	928	823	550	340	

5.9.2.3.2. Discards

Discards were reported to SGMED-10-02, as noted in SGMED-09-02, for 2005 and 2006 only. Total discard for hake was 15 t in 2005 for long-lines and 63 t in 2006 for trawlers.

5.9.2.3.3. Fishing effort

The reported fishing effort values through the DCF data call was not updated for 2009. Also, there was still lack of 2008 data, because those reported where apparently wrong and most of all completely different from SGMED-09-02. In particular, days, GT*days and kW*day seems to be underestimated for OTB, which is the main fleet segment harvesting hake. Using data reported in SGMED-09-02, the trends in fishing effort by year and major gear type is listed in Tab. 5.9.2.3.3.1 and shown in Fig. 5.9.2.3.3.1 in terms of kW*days. Similar to the trend in total fishing effort, the trend in fishing effort by trawler appears rather stable.

Tab. 5.9.2.3.3.1 Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2002-2007. In 2009, no values were reported for 2008.

FT_LVL4	2002	2003	2004	2005	2006	2007
FPO				79031	824017	1387022
FYK						13055
GND						11713
GNS				1007963	236313	781402
GTR				6358014	6476994	4393484
LHP-LHM				769	70523	122621
LLD				284297	480411	952876
LLS				832709	1159412	1054615
LTL					12388	1622
OTB				7679721	5879355	5957347
DTS	3679604	4652647	6711626			
PGP	2865738	5099814	7105771			
PMP	7159338	3245118				
total	13704680	12997579	13817397	16242504	15139413	14675757

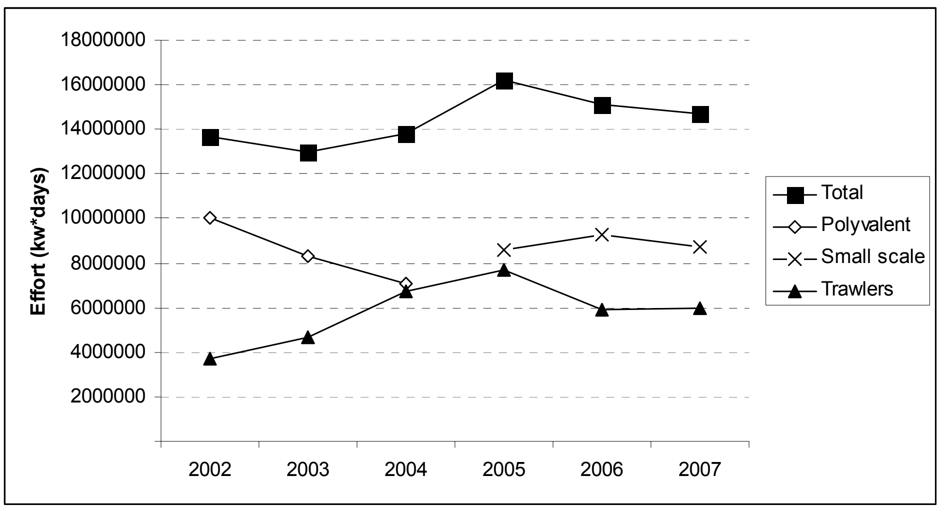


Fig. 5.9.2.3.3.1 Trend in fishing effort (kW*days) for the Italian fleet in GSA 11 for the major gear types in 2002-2007. In 2009, no values were reported for 2008.

Tab. 5.9.2.3.3.2 Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2004-2008, as reported through the DCF in 2010.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LE	2003	2004	2005	2006	2007	2008
11	ITA	FPO	DEMSP		VL0006					8227	1107
11	ITA	FPO	DEMSP		VL0612				13379	69823	43856
11	ITA	FPO	DEMSP		VL1218					16165	4731
11	ITA	FYK	DEMSP		VL0006						0
11	ITA	GNS	DEMSP		VL0006				0	3950	2439
11	ITA	GNS	DEMSP		VL0612		22701	54787	5413	44336	35469
11	ITA	GNS	DEMSP		VL1218		5248	39173	9568	7130	19593
11	ITA	GTR	DEMSP		VL0006				5465	5988	4328
11	ITA	GTR	DEMSP		VL0612			38115	82656	176487	116844
11	ITA	GTR	DEMSP		VL1218		1814	54332	19069	75188	64023
11	ITA	LHP-LHM	CEP		VL0006					4305	1131
11	ITA	LHP-LHM	CEP		VL0612		3065		2611	9764	3353
11	ITA	LHP-LHM	CEP		VL1218					12237	4371
11	ITA	LHP-LHM	FINF		VL0612						3480
11	ITA	LLD	LPF		VL1218			6694			
11	ITA	LLD	LPF		VL2440					1975	
11	ITA	LLS	DEMF		VL0006				228	2263	0
11	ITA	LLS	DEMF		VL0612		50046	61709	4253	76836	29234
11	ITA	LLS	DEMF		VL1218		3499	34499	20040	43290	25525
11	ITA	LLS	DEMF		VL2440					13170	
11	ITA	OTB	DEMSP		VL1218		75568	77835	108842		95470
11	ITA	OTB	DEMSP		VL1824						66067
11	ITA	OTB	DEMSP		VL2440						22082
11	ITA	OTB	MDDWSP		VL1218					152444	8561
11	ITA	OTB	MDDWSP		VL1824		115969	188926	141391	195889	35045
11	ITA	OTB	MDDWSP		VL2440		213246	234872	190232	187054	126564
11	ITA	PS	SPF		VL1218		4109				

5.9.3. Scientific surveys

5.9.3.1. MEDITS

5.9.3.1.1. Methods

Since 1994 the MEDITS trawl surveys have been yearly carried out between May and July (except in 2007). According to the MEDITS protocol (Relini, 2000; Bertand *et al.*, 2002) a stratified random sampling design with allocation of hauls proportional to depth strata extension (depth strata: 10–50 m, 51–100 m, 101–200 m, 201–500 m, 501–800 m) was adopted. A specific gear (GOC 73, with a 20 mm stretched mesh size in the cod-end) was always used following the instruction stated and reported in Dremière and Fiorentini (1996).

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 11 the following number of hauls was reported per depth stratum (s. Tab. 5.9.3.1.1.1).

Tab. 5.9.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18
GSA11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20
GSA11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24
GSA11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19
GSA11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).
The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.9.3.1.2. Geographical distribution patterns

The spatial distribution of European hake has been described by modelling the spatial correlation structure of the abundance indices using geostatistical techniques (i.e. kriging). In different studies either total abundance index or abundances of recruits and adults were analysed (Murenu *et al*., 2007).

On average, considering the analyzed yearly distributions (1994-2005), the recruits were considered individuals smaller than 12.3 cm (±1.41). These individual are belonging to the age 0 group. Persistence of the nursery areas along the years was studied by applying indicator kriging technique (Journel 1983, Goovaerts, 1997) to abundance estimations of recruits (Murenu *et al*., 2008). Main results and maps are reported in the "nursery section" of SGMED-09-02 report.

5.9.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 11 was derived from the international survey MEDITS. Figure 5.9.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 11.

The estimated abundance and biomass indices since 2000 show high variation without any trend.

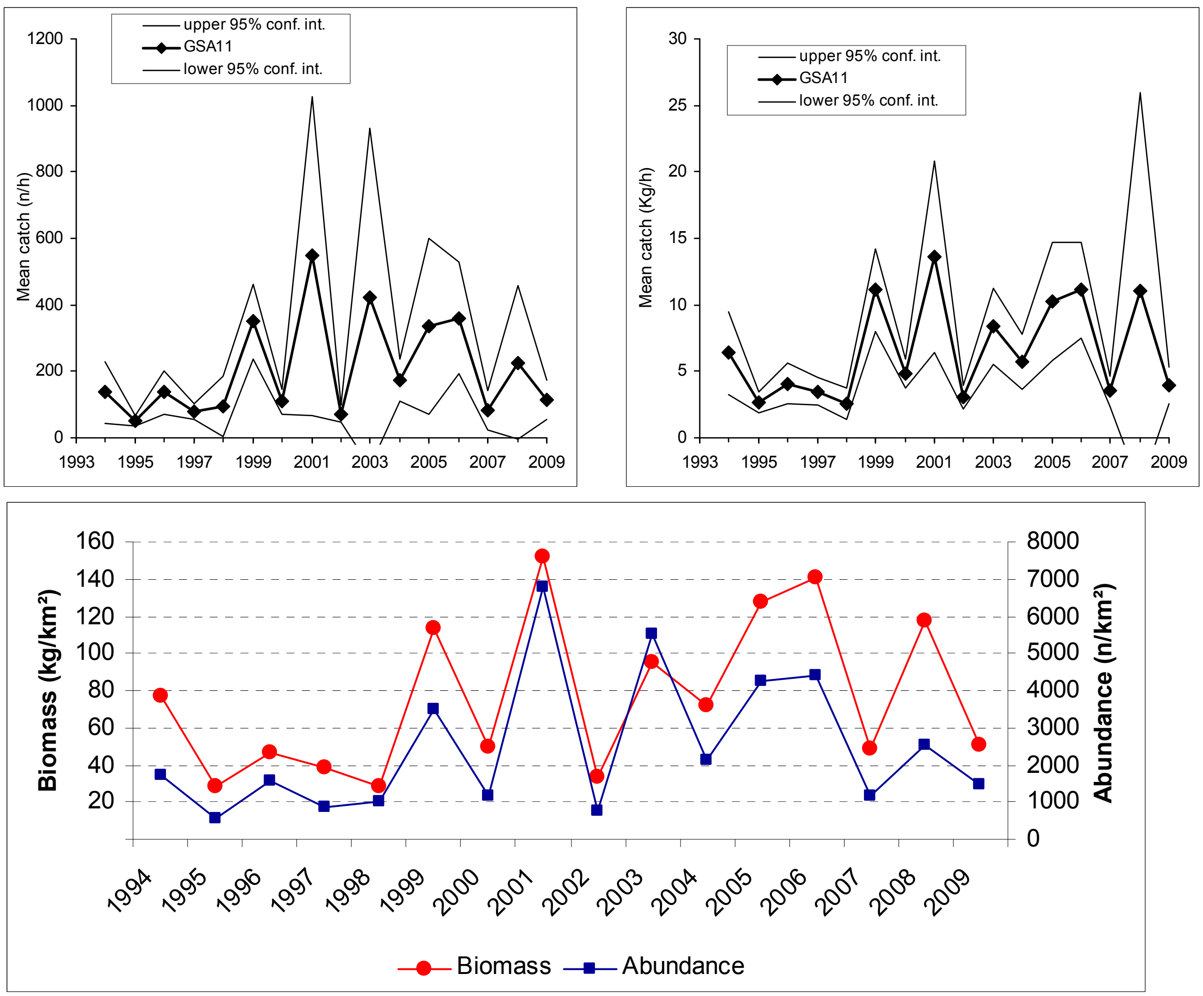


Fig. 5.9.3.1.3.1 Abundance and biomass indices of hake in GSA 11.

5.9.3.1.4. Trends in abundance by length or age

The following Fig. 5.9.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2001 and 2002-2009 respectively.

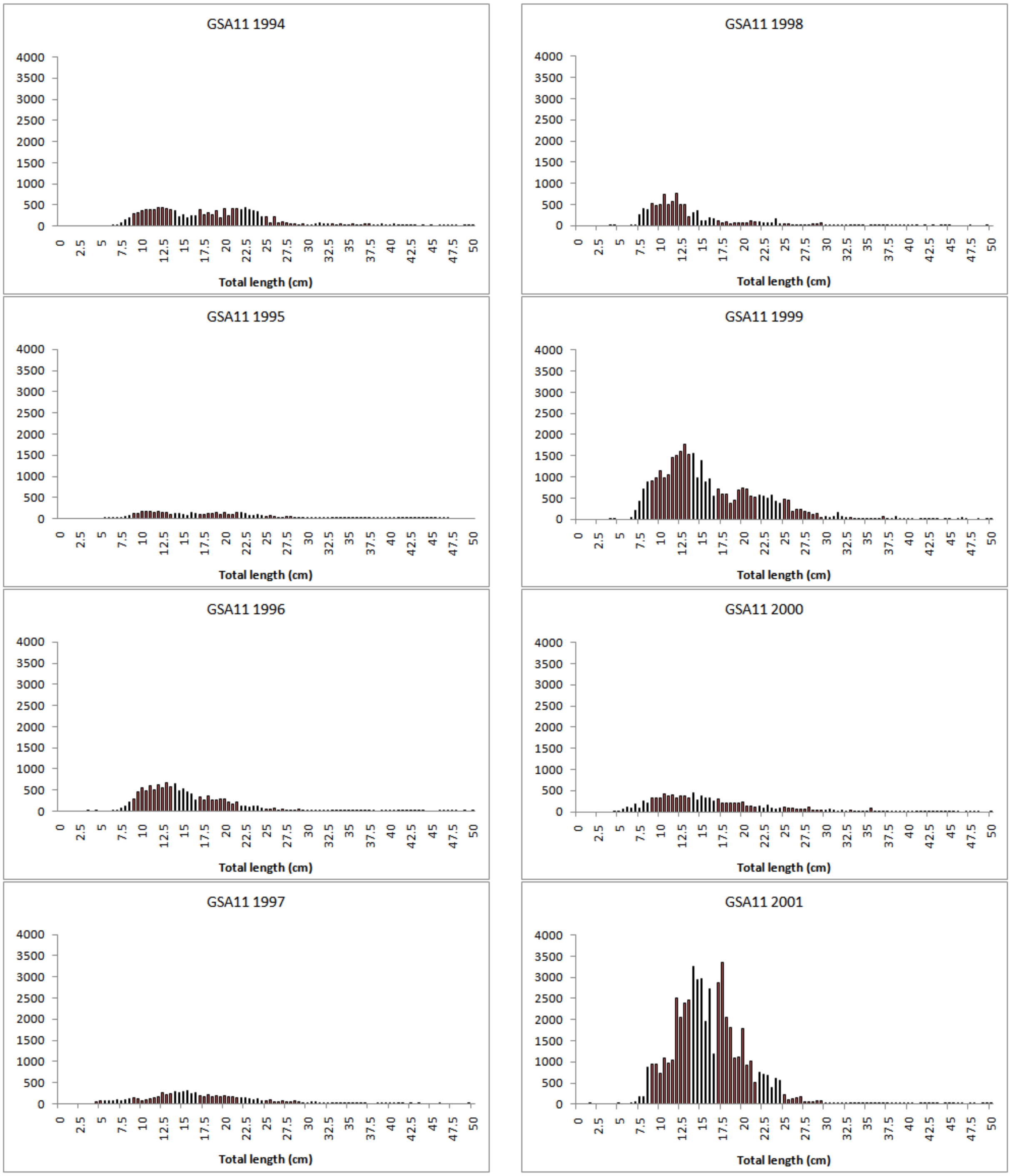


Fig. 5.9.3.1.4.1 Stratified abundance indices by size, 1994-2001.

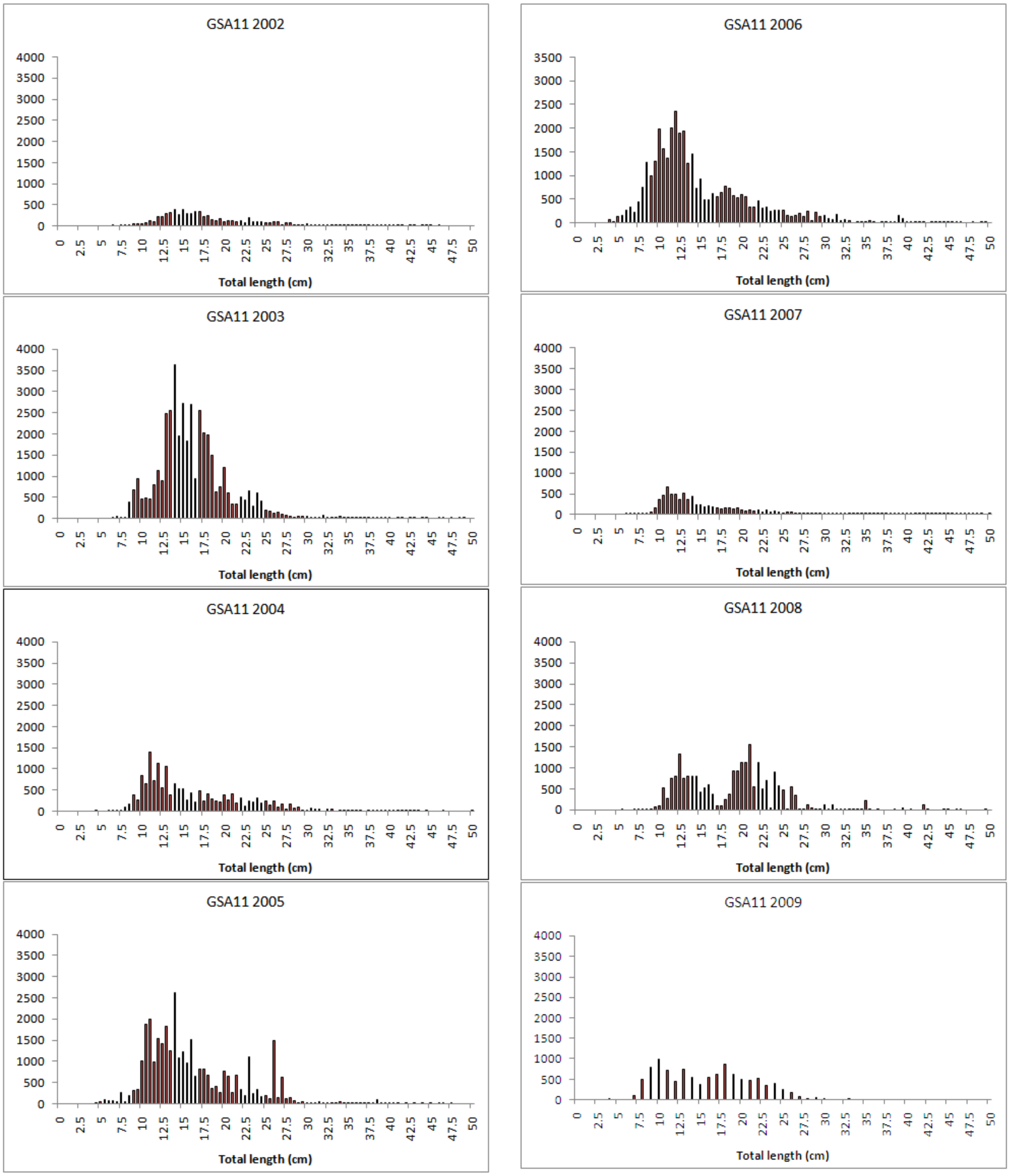


Fig. 5.9.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.9.3.1.5. Trends in growth

No analyses were conducted.

5.9.3.1.6. Trends in maturity

No analyses were conducted.

5.9.4. Assessment of historic stock parameters

5.9.4.1. Method 1: SURBA

5.9.4.1.1. Justification

The SURBA analyses was applied to the MEDITS survey estimates.

5.9.4.1.2. Input parameters

Data from trawl surveys (time series of MEDITS from 1994 to 2009) and effort and landings data from DCR have been used for the analysis. The SURBA software package (Needle, 2003) use trawl surveys data available from MEDITS to estimate fishing mortality rates of hake in the GSA 11. First, the LFDs were converted in numbers at age using the subroutine "age slicing" as implemented in the R routine by SGMED. The VBGF parameters used to split the LFD has been changed from L_∞=97.15 cm, K=0.165, t_0= 0.03 used in SGMED-09-02 to a faster growth set as L_∞=100 cm, K=0.248, t_0= -0.01. According to the Prodbiom approach developed by Caddy and Abella (1999), a vectorial natural mortality at age was estimated (Tab. 5.9.4.1.2.1). Guess-estimates of catchability by age are given in Tab. 5.9.4.1.2.1.

Tab. 5.9.4.1.2.1 Input parameters used in the SURBA analysis (sex combined) in GSA11.

VBGF	L_∞=100 cm, K=0.248, t_0= -0.01
M vector	Age_1=1.11 , Age_2=0.51, Age_3=0.40, Age_4=0.35, Age_5=0.33
Catchability (q)	q_1 = 0.8, q_{2-3} = 1.0, q_4=0.75, q_5=0.6
Length at maturity (L_{50})	36 cm (sex combined)

5.9.4.1.3. Results

Estimates of total mortality for sex combined from Surba were as follows: SURBA results show that the mean F for ages 1-3 was high and stable until 2005, then increasing up to 3.1 in 2008.

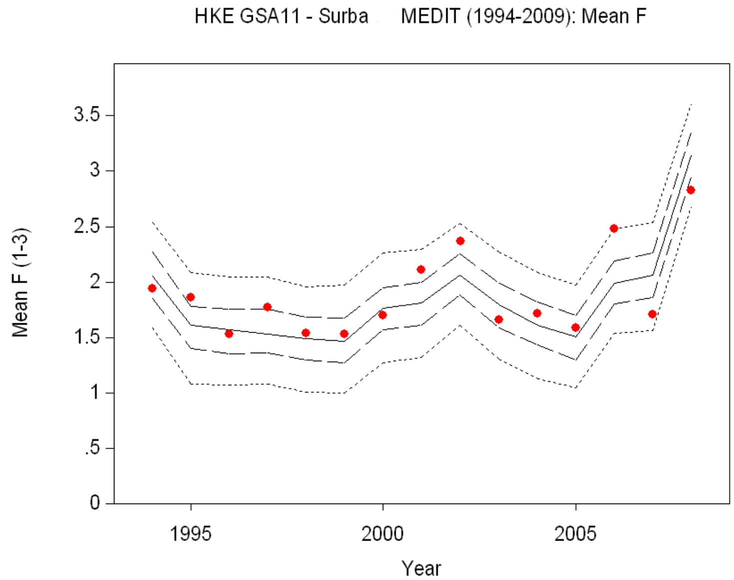


Fig. 5.9.4.1.3.1 Fishing mortalities estimated by SURBA using trawl surveys age composition (MEDITS).

SSB peaks were detected in 1994, 2000 and 2006, with a clear drop in the last years. Relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2009, with large recruitment observed in 2001, 2003 and 2005.

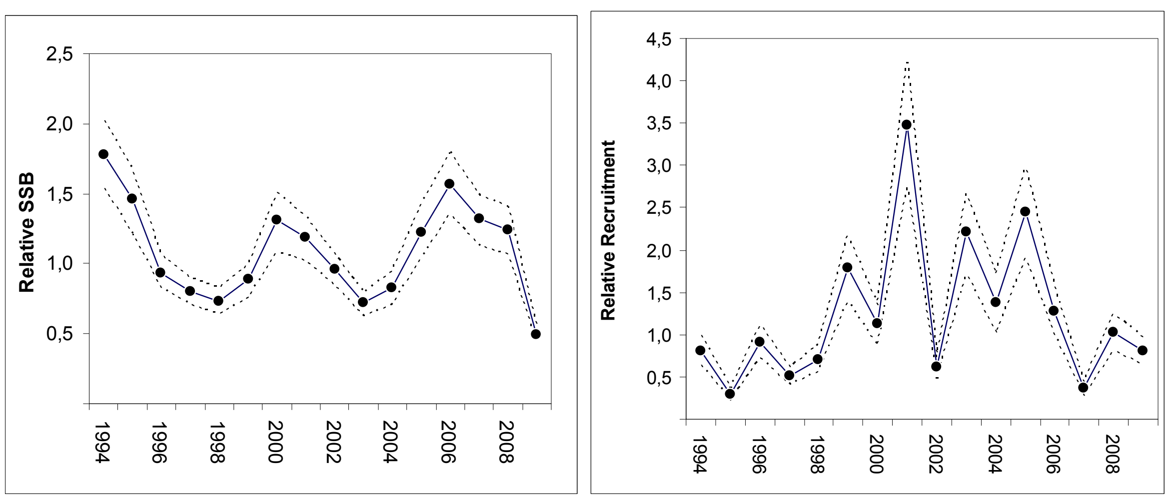
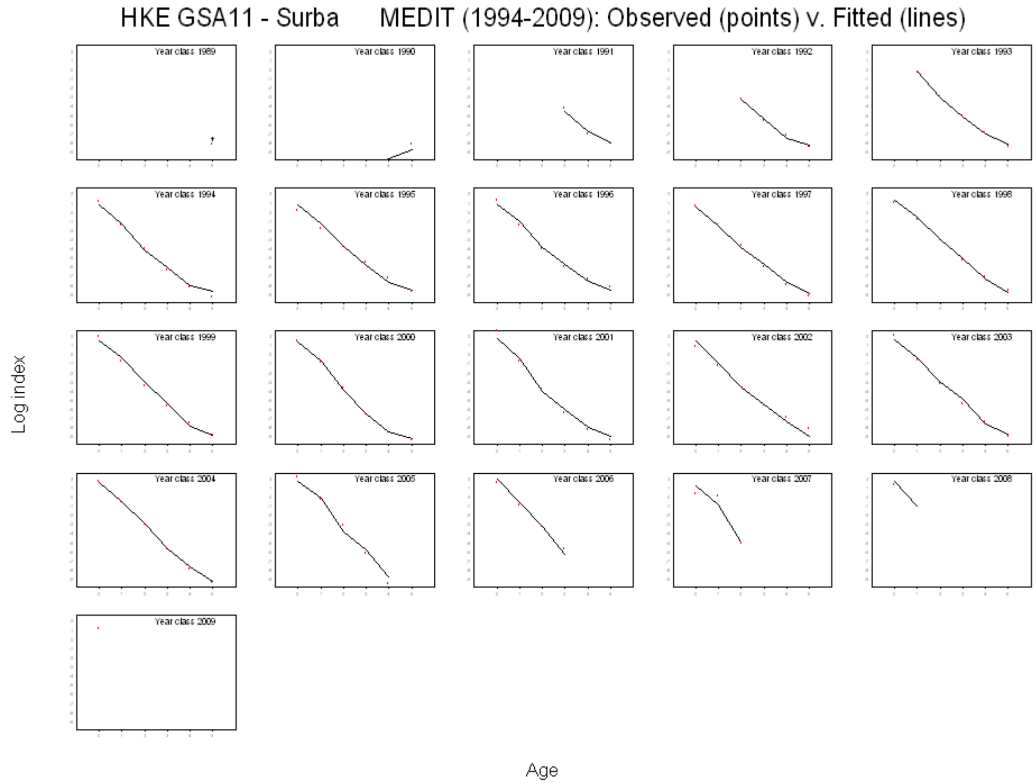


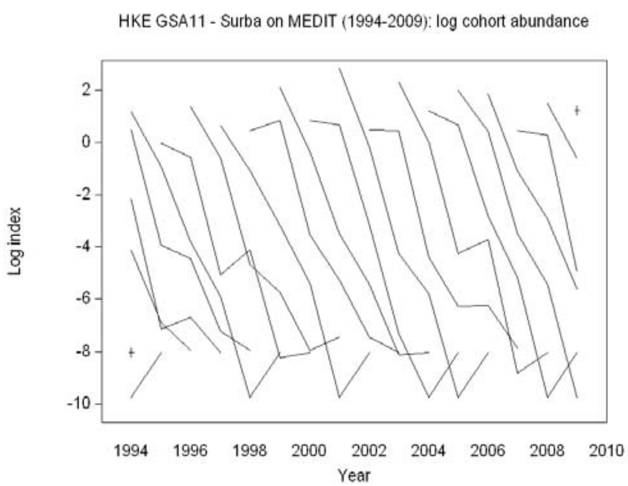
Fig. 5.9.4.1.3.2 Trend of SSB and recruitment estimated by SURBA using trawl surveys data (MEDITS).

Model diagnostics are shown in the Fig. 5.9.4.1.3.3. Observed and fitted MEDITS survey indices of abundance for each year were reasonably in agreement (A) while catch curve reconstruction from log survey abundance indices showed some deviation from the expected curve (B). Log index residuals over time, plotted by age class (C) varied without any trend.



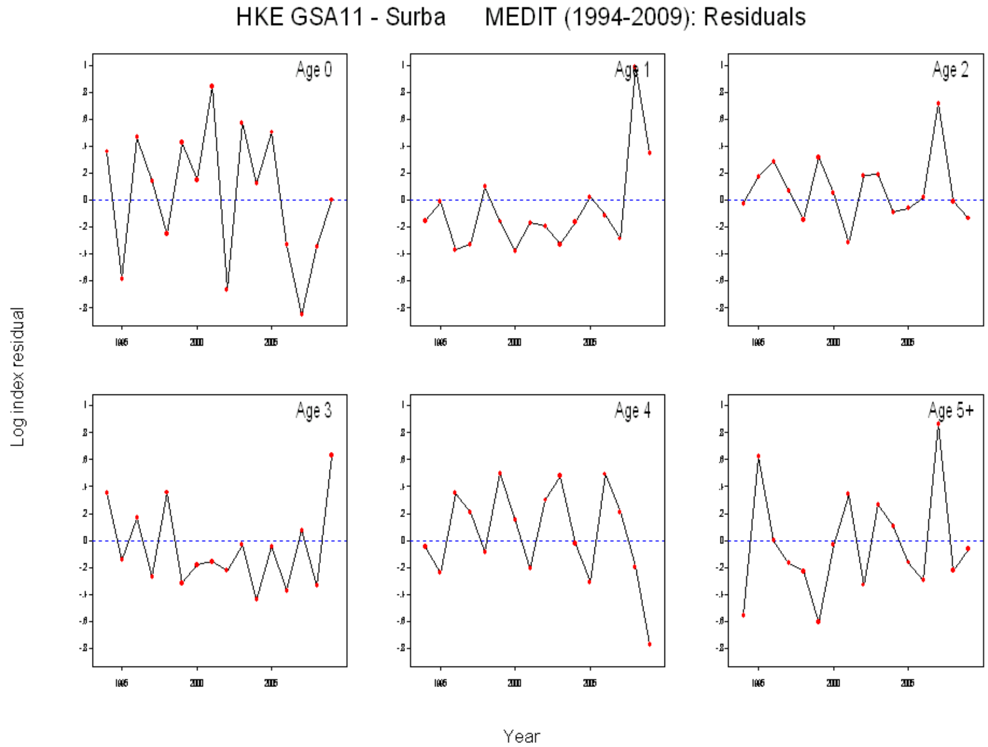
HKE GSA11 - Surba MEDIT (1994-2009): Observed (points) v. Fitted (lines)
Year class 1989
Year class 1990
Year class 1991
Year class 1992
Year class 1993
Year class 1994
Year class 1995
Year class 1996
Year class 1997
Year class 1998
Year class 1999
Year class 2000
Year class 2001
Year class 2002
Year class 2003
Year class 2004
Year class 2005
Year class 2006
Year class 2007
Year class 2008
Year class 2009
Log index
Age

A



HKE GSA11 - Surba on MEDIT (1994-2009): log cohort abundance
Log index
2
0
-2
-4
-6
-8
-10
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

B



C

Fig. 5.9.4.1.3.3 Model diagnostic for SURBA model in the GSA 11 (MEDITS survey). A) Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life. C) Log index residuals over time, plotted by age class.

5.9.5. Long term prediction

5.9.5.1. Justification

State of the stock in relation to reference points was estimated using Yield software (Hoggarth *et al*., 2006).

5.9.5.2. Input parameters

The parameters used were adopted from the SURBA analysis presented above.

5.9.5.3. Results

$F_{0.1}$ was assumed as target reference point. F_{max} and F_{ref} were considered as limit reference points. F_{ref} is the F where the ratio SSB/initial SSB is equal to 0.30. The following mean values were obtained: F_{max} = 0.28; $F_{0.1}$= 0.19 and F_{ref}= 0.26.

5.9.6. Data quality

MEDITS survey data were available from 1994 with few minor errors for 2009 in JRC database that need to be corrected, while landing and effort data quality and availability was rather low. In particular, landings derived from LLS, GNS and GTR seem to be overestimated for the period 2004-2008 while are completely lacking for 2009. Landings for 2002 and 2003 are not comparable with those reported in previous data call and appear to be given in kg rather than in metric tons. Landings by length class for 2008 have been expanded while they have not for 2006 and 2007. Discards have been reported for 2005 and 2006 only. The effort data are lacking for 2008 and 2009, while fishing days seems to be underestimated for OTB in 2005, 2006 and 2007. Moreover different and contradictory versions of the same archive (ex MED_02_EFF) increase the perception of low quality of reported data. Uncertainty in the quality of fishery dependent data did not allow SGMED to run a VIT analysis for this stock. To improve the quality of SGMED a full validation of the data submitted by the Italian authorities through the official DCF data call should be performed as a matter of urgency.

5.9.7. Scientific advice

5.9.7.1. Short term considerations

5.9.7.1.1. State of the spawning stock size

Due to the lack of validated landings information, SGMED-10-02 was not in the position to estimate the absolute levels of stock abundance. Survey abundance (n/km²) and biomass (kg/km²) indices do not indicate a significant trend. The stock SSB is more variable over the last decade.

No biomass reference points have been proposed for this stock. As a result, SGMED is unable to evaluate the status of the stock with respect to biomass.

5.9.7.1.2. State of recruitment

Due to the lack of validated landings information, SGMED-10-02 was not in the position to estimate the absolute levels of recruitment. Relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2009, with a clear decreasing trend in the last five years.

5.9.7.1.3. State of exploitation

Trends in the average fishing mortality over ages 1 to 3 derived from MEDITS surveys ranged from 1.5 to 3.1, with the highest value observed in the last year. SGMED notes that the current F is far in excess of the proposed target reference point $F_{0.1}$. Assuming a similar selection patters of the survey and the commercial fishery, SGMED concludes that the hake stock in GSA 11 is heavily overfished.

5.10. Stock assessment of hake in GSAs 15 and 16

5.10.1. Stock identification and biological features

5.10.1.1. Stock Identification

Eggs, larvae and post larvae of *M. merluccius* are pelagic and usually associated with the shelf, peaking in abundance between 100 and 200 m depth. The transition from the pelagic to the benthic habitat occurs when young individuals reach a size of about 3 cm total length (Colloca, 1999). Despite the fact that very small specimens of 3.5 cm total length (Sinacori G., pers. com.; hereafter TL) were caught during trawl surveys, hake is only considered fully recruited to grounds at 10 cm TL (SAMED, 2002). Contrasting with other areas of the Mediterranean, where two main recruitment pulses are known (Orsi Relini *et al*., 2002), the analysis of the length frequency distribution through year suggest that in GSA 15 and 16 hake recruits all year round (SAMED, 2002).

The stock structure of hake in the Strait of Sicily has to date not been defined. Levi *et al*. (1994) compared the growth of *M. merluccius* in Mediterranean and found quite a similar pattern in individuals from the Northern side of the Strait of Sicily (GSAs 15 and 16) and those caught in the Gulf of Gabes (GSA 14). Lo Brutto *et al*. (1998) have also found no evidence of genetic subdivisions or significant differences in allelic frequencies, between samples near Sicily and those from the mid-line. More recently Levi *et al*. (2004) applied electrophoretic, morphometric and growth analyses to test the hypothesis of the existence of a unique stock of hake in the Sicily channel, which includes part of the North African continental shelf off the Tunisian coast and the shelf off the southern Sicilian coast. Although the level of genetic variation detected at five selected sampling sites was very low, morphometric analyses and otolith readings revealed some significant differences at phenotypic level, mainly in females. On the basis of the spatial distribution of spawning and nursery areas compared with the current patterns in the Strait of Sicily, Camilleri *et al*. (2008) believed the existence of genetic exchange between hake sub-populations inhabiting GSAs 15 and 16. In the northern sector of the Strait of Sicily (GSA 15 and 16), although some inter-annual variability in the nurseries distribution was evident, Abella et al. (2008) identified two stable nursery areas, which are related with prevailing meso-scale oceanographic processes. These nurseries areas are located on the eastern side of the Adventure and Malta banks, between 100 and 200 m depth (Fig. 5.10.1.1.1).

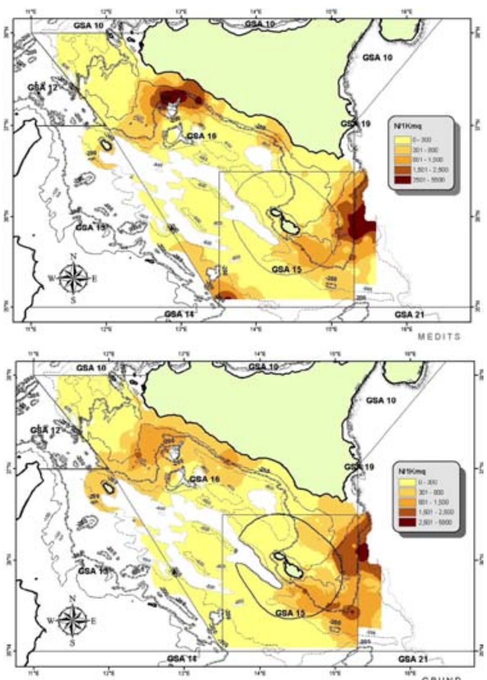


Fig. 5.10.1.1.1. Mean pattern of highest concentration of recruits in the Strait of Sicily in Spring (MEDITS surveys) and Autumn (GRUND surveys; Abella *et al.*, 2008).

A study by Andaloro *et al*. (1985) in the Strait of Sicily found that hake's diet varied according to size. Smallest fish of 4.5-12 cm TL feed mainly on Euphausiacea. Decapods are the main preys of hake between 13 and 24 cm TL, while fish is the preferred food of individuals larger than 25 cm TL. Similar feeding behaviour that varied with size has also been observed for other areas in the Mediterranean (see Colloca 1999).

5.10.1.2. Growth

Parameters of the length-weight relationship are listed in Table 5.10.1.2.1.

Tab. 5.10.1.2.1. Parameters of length-weight relationships of hake in the GSAs 15 and 16.

Author	GSA	Sex	a	b
Andaloro *et al*., 1985	16	F+M+I	0.0060	3.1190
Cannizzaro *et al*., 1991	15 & 16	F	0.0069	3.0248
		M	0.0068	3.0222
		F+M+I	0.0066	3.0370
IRMA-CNR, 1999	15 & 16	F+M+I	0.0056	3.0831
CNR-IAMC, 2006	16	F	0.0041	3.1669
		M	0.0051	3.0916
		F+M+I	0.0046	3.1341
CNR-IAMC, 2007	16	F	0.0043	3.1525
		M	0.0049	3.1028

Considering the northern sector of the Strait of Sicily (GSA 15 and 16) the observed maximum length is 88 cm TL in females (Fiorentino *et al*., 2003) and 53 cm TL in males (Sinacori G., pers. com.). According to Fiorentino *et al*. (2003), the maximum estimated age in years in the stock, was 15 years. This was established by thin section otolith lectures of largest females collected in trawl surveys for over 15 years.
The Von Bertalanffy Growth Function parameters by sex available for GSAs 15 and 16 are reported in Table 5.10.1.2.2.

Tab. 5.10.1.2.2 Von Bertalanffy growth function parameters of hake in the strait of Sicily and adjacent seas.

Author	GSA	***Females***			**Males**			Remarks
		$L\infty$	K	t_0	$L\infty$	K	t_0	
Andaloro *et al*. (1985)	16	69.40	0.14	-0.35	57.1	0.16	-0.39	Otolith readings
IRMA-CNR, 1999	15&16	70.54	0.18	-0.1	49.37	0.29	-0.01	LFD analysis
SAMED, 2002	15&16	76.4	0.16	-0.2	44.9	0.28	-0.2	LFD analysis
Gangitano *et al*., 2007	16	82.60	0.12	-0.91	52.2	0.22	-0.83	Otolith reading
CNR_IAMC; 2007	16	81.54	0.15	-0.08	53.58	0.22	-0.13	Otolith readings and LFDA

With the exception of Andaloro *et al*. (1985), hake showed similar growth patterns in populations inhabiting the Strait of Sicily and the adjacent seas. Excluding the values given by Andaloro *et al*. (1985), the mean growth rates per month during the first two years range between 0.92 and 1.1 cm in females and 0.86 and 1.0 cm in males. These rates are compatible with those reported for juvenile hake in the Mediterranean by Fiorentino *et al*. (2000).

Recently, results given by otolith reading were considered as underestimating growth due to the presence of several checks, which can be confused with year rings. However the mean growth rates obtained for the first two years are consistent with those given by de Pontual *et al*. (2003), based on tagging experiments in the Bay of Biscay (0.84-0.99 cm per month in a size range of 21-40 cm TL).

5.10.1.3. Maturity

On the basis of trawl landings data (GSA 15 & 16) sex ratio is around 0.5 between 24 and 32 cm TL, while females prevail mainly at larger sizes (SR≥0.90 after 40 cm TL) (Figure 5.10.1.3.1). In GSA 16 sex ratios from trawl surveys shows a significant decrease (r_s=-0.657) with time, showing a reduction of females in the population since 1994 (Figure 5.10.1.3.2).

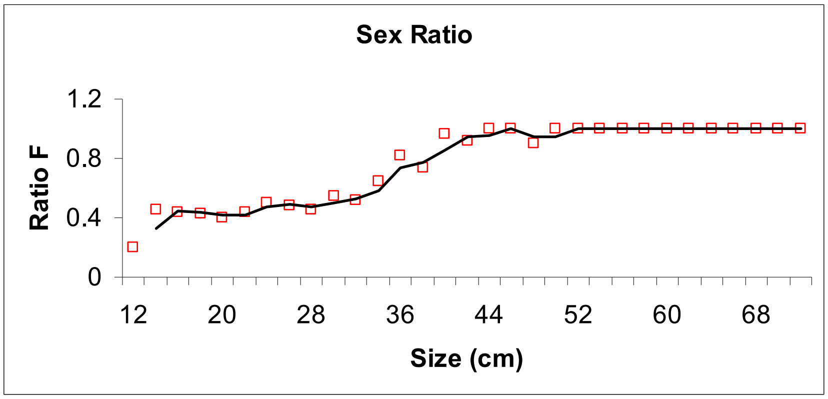


Fig. 5.10.1.3.1. Ratio of female *M. merluccius* in the Strait of Sicily based on landings data; black line represents moving average.

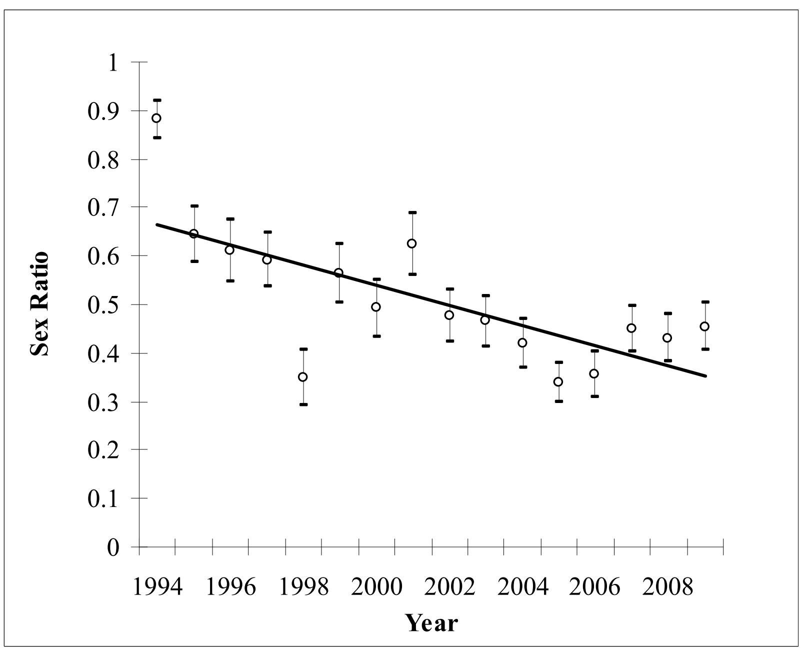


Fig. 5.10.1.3.2. Hake sex ratio in the Straight of Sicily based on MEDITS survey data from 1994-2009.

Although spawning off Tunisia (GSA 12) occurs all over the year, Bouhlel (1973) reported three maturity peaks, in summer, winter and spring depending to the size of females. The largest females (LT> 40 cm) spawn mainly in spring, while the smallest (29<TL<39 cm) have two main spawning peaks, one in summer and another one in winter. Bouaziz *et al*. (1998), studied samples from Bou-Ismail (GSA 4) and reported that the spawning season runs throughout the whole year, even if a peak in summer is evident. According to Levi (1991), mature specimens were collected both in autumn (November) and winter (February) in GSA 15 and 16. Information from the northern sector of the Strait of Sicily (GSA 16) revealed that outer shelf on the western side of Adventure Bank might be a relevant spawning area (Fiorentino *et al*., 2006). According to literature spawning should occur in the outer shelf-upper slope. For instance, aggregation of mature adults was reported between 100 and 200 m in the Gulf of Tunis (Bouhlel, 1973). Available estimates of length at first maturity for the Strait of Sicily are reported in Table 5.10.1.3.1.

Tab. 5.10.1.3.1 Length at first maturity, as $L_{50\%}$ of maturity oogive, for hake in the Strait of Sicily and adjacent seas.

Author	**GSA**	**Females**		**Males**	
		L50%	**g**	**L50%**	**g**
Bouhlel, 1973	12 & 13	30.5	n.a.	28	n.a.
Mugahid & Hashem, 1982	21	24.5 (30)	n.a.	21	n.a.
Bouaziz *et al*., 1998	4	30.6	n.a.	21.5	n.a.
SAMED, 2002	15 & 16	33.5	n.a.	n.a.	n.a.
Gangitano *et al*., 2007	16	37.6	0.288	27.8	0.329
CNR_IAMC, 2007	15 & 16	35.6	0.29	24.6	0.23

5.10.2. Fisheries

5.10.2.1. General description of fisheries

Although hake is not a target of a specific fishery, such as deep water pink shrimp and striped mullet, it is the third species in terms of biomass landed in GSA 16 (Fiorentino *et al*., 2005). Hake is caught by trawling in a wide depth range (50-500 m) together with other important species such as *Nephrops norvegicus*, *Parapenaeus longirostris*, *Eledone* spp., *Illex coindetii, Todaropsis eblanae*, *Lophius* spp., *Mullus* spp., *Pagellus* spp., *Zeus faber, Raja* spp. among others. In 2004-2008, 98.5% of catches declared in Sicily were caught by demersal otter board trawlers. Only 1% of catches were obtained using longlines, and 1.5% using trammel nets.

A rough delimitation of the most important commercial macro-areas for a large part of the Strait of Sicily is reported in Andaloro (1996). The main fishing-grounds, the species caught, the fishing periods and other relevant information regarding the Mazara distant trawl fleet fishing for hake in the Strait of Sicily are reported in Fiorentino *et al*. (2008). Detailed maps of the trawling grounds inside the Maltese Fisheries Management Zone (FMZ), which includes a substantial part of GSA 15, are available in Camilleri *et al*. (2008).

Trawlers operating in the Strait of Sicily use the same typology of trawl net called "Italian trawl net". Although some differences in material between the net used in shallow waters ("banco" net, mainly targeting shelf fish and cephalopods) and that employed in deeper ones ('fondale' net, mainly targeting deep water crustaceans) exist, the Italian trawl net is generally characterized by a low vertical opening (up to 1.5 m). However dimensions change with engine power (Fiorentino *et al*., 2003).

5.10.2.2. Management regulations applicable in 2009 and 2010

As in other areas of the Mediterranean, stock management measures are based on the control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06).

In order to limit the over-capacity of fishing fleets, Italian fishing licenses have been fixed since the late 1980s. Moreover, after 2000, in agreement with the European Common Fisheries Policy, a gradual decrease of fleet capacity was put into place. From 1987 to 2005 a 30-45 days stopping of fishing activities was enforced each year, in order to reduce fishing effort. Furthermore a medium term management plan (2008-2013) was agreed for Italian trawlers, in part fulfilment of regulation EC 1967/2006.

In Malta the trawling fleet was stable with 16 licensed trawlers from 2000-2008. In 2008, due to a reduction in capacity of other fleets, 8 new trawl licenses were issued, thus increasing the trawl capacity for Malta by 50%. The Maltese Islands are surrounded by a 25 nautical miles (nm) fisheries management zone, where fishing effort and capacity are being managed by limiting vessel sizes, as well as total vessel engine powers (EC 813/04; EC 1967/06). Trawling is allowed within this designated conservation area, however only by vessels not exceeding an overall length of 24m and only within designated areas. Such vessels fishing in the management zone hold a special fishing permit in accordance with Article 7 of Regulation (EC) No 1627/94, and are included in a list containing their external marking and vessel's Community fleet register number (CFR) to be provided to the Commission annually by the Member States. Moreover, the overall capacity of the trawlers allowed to fish in the 25 nm zone can not exceed 4 800 kW, and the total fishing effort of all vessels is not allowed to exceed an overall engine power and tonnage of 83 000 kW and 4 035 GT respectively. The fishing capacity of any single vessel with a license to operate at less than 200 m depth can not exceed 185 kW. In addition, the use of all trawl nets within 1.5 nm of the coast is prohibited according to EC regulation 1967/2006, although again a transitional derogation is at present in place until 2010. There are no closed seasons in Maltese waters.

In terms of technical measures, the new regulation EC 1967 of 21 December 2006 fixed a minimum mesh size of 40 mm for bottom trawling of EU fishing vessels (Italian and Maltese trawlers). Minimum mesh sizes have to be modified to square 40 mm or diamond 50 mm by June 2010; hereafter no further derogations are possible. The minimum landing size for *M. merluccius* is at present 20 cm (Annex III, EC 1967/2006).

In addition to these management measures, the protection of spawning grounds has been suggested to be one of the most effective management approaches to enhance recruitment whilst maintaining the reproductive potential of populations. Similarly, reducing fishing mortality on juveniles is vital if populations are to be harvested at maximum sustainable yield, in particular when juveniles are vulnerable to unselective fishing gears. The location of nursery areas of *M. merluccius* in the Strait of Sicily have been identified using data from MEDITS and GRUND trawl surveys carried out in GSA 16 (Abella *et al.* 2008). However, the location of hake nurseries were found to be located at discrete off-shore areas on the outer shelf (100-200 m) in international waters, making the possibility of protecting the nursery areas a difficult task especially with respect to enforcement. Nevertheless, both Malta and Italy authorities suggested setting up a Fishing Restricted Area (FRA) on Malta Bank in their national fisheries management plans currently submitted to the European Commission (as required by Article 18 of EC 1967/2006).

5.10.2.3. Catches

5.10.2.3.1. Landings

The most recent Italian and Maltese data were collected within the EU Data Collection Framework (DCF). Landings data from 2009 were not submitted by the Italian and Maltese authorities. Andreoli *et al*. (1995) estimated yield of hake landed by trawling with 1-2 day trip of commercial fisheries of southern coasts of Sicily (GSA 15 and 16) in the middle eighties: in April 1985 - March 1986 landings of about 1440 tons were recorded; the next year it amounted to 1238 tons. Considering that the overall yield of trawling was about 15337 tons in 2007 and 13249 tons in 2008, hake landings represent about 10% of total demersal trawl yields in the area (see Table 5.10.2.3.1.1). On the basis of 2007 data, 93% of Sicilian landings are due to trawling. In 2008, this percentage decreased to 72.4%.

Tab. 5.10.2.3.1.1 Landings (t) of hake by fishing technique by the Sicilian fleet as recorded under the EU DCF.

	Landings (tonnes)			
Year	Demersal Trawls (OTB)	Longlines (LLS)	Pelagic Trawls (OTM)	Trammel Nets (GTR)
2004	1949	0.1	/	0.0
2005	1720	23.2	/	46.3
2006	1598	22.2	/	6.3
2007	1599	35.7	/	83.4
2008	1367	11.6	0.1	15.9

Overall, hake landings decreased for demersal trawlers measuring >24 m in length, but remained stable for trawlers measuring 12-24 m in length.

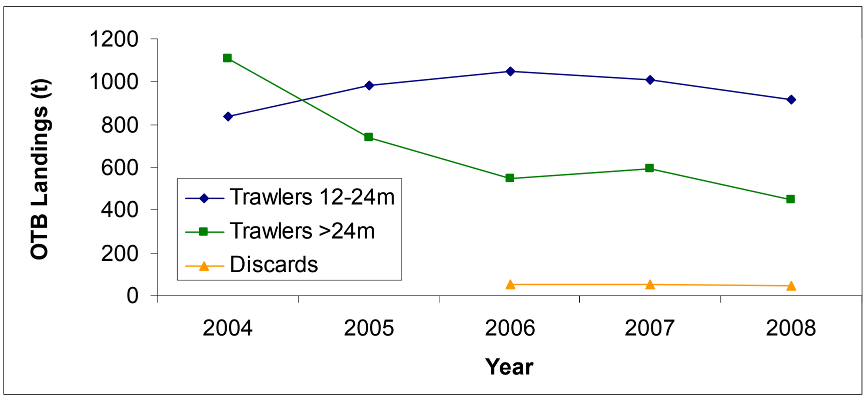


Fig. 5.10.2.3.1.1. Sicilian hake yield, fished in GSA 15 and 16, by each fleet segment. Discards are shown for both fleets combined.

Length compositions of landings for Sicilian vessels reveal that trawlers measuring 12-24 m fish a higher percentage of small individuals compared to trawlers measuring over 24 m in length.

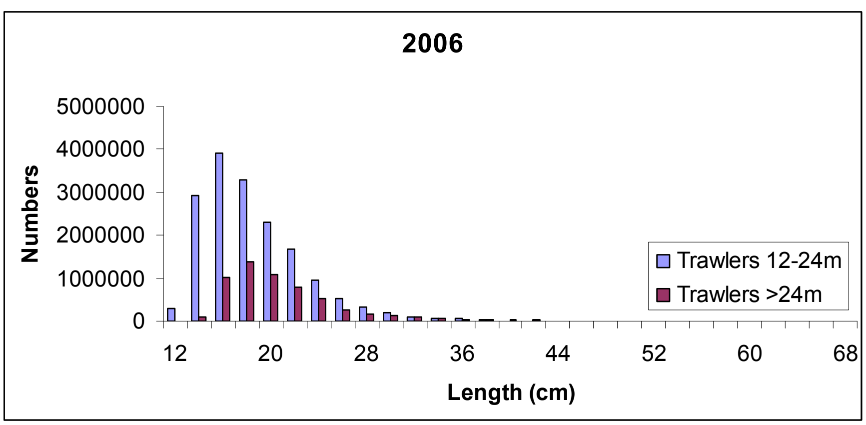


Fig. 5.10.2.3.1.2. 2006 length structures of hake landings by Sicilian trawlers in absolute numbers.

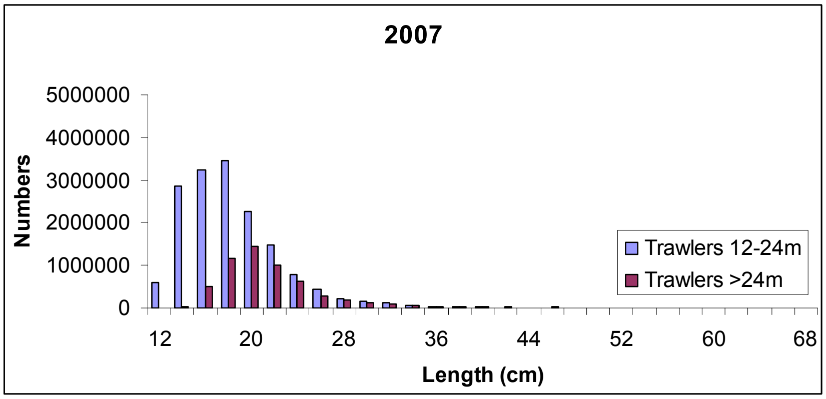


Fig. 5.10.2.3.1.3. 2007 length structures of hake landings by Sicilian trawlers in absolute numbers.

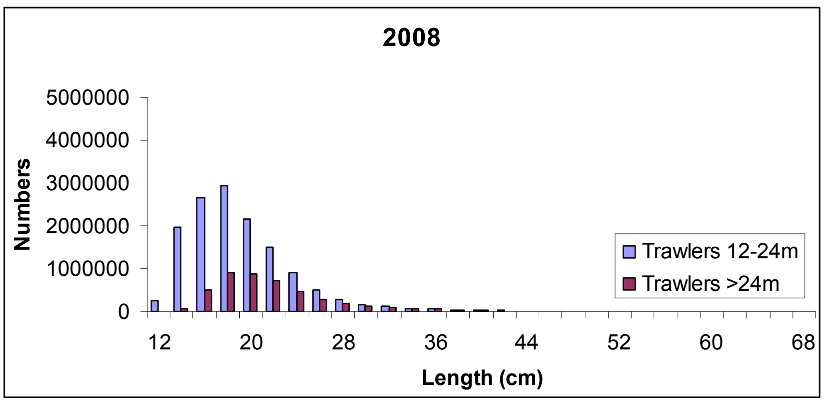


Fig. 5.10.2.3.1.4. 2008 length structures of hake landings by Sicilian trawlers in absolute numbers.

5.10.2.3.2. Discards

In the late nineties Sicilian trawlers fishing off-shore (15 – 25 days of trip) had higher discard rates of hake (86% in number and 31% in weight of the total catch) than the inshore trawlers (1-2 days trips) (32% in number and 9% in weight) (Anon., 2000). For distant fisheries the first modal group (10-12 cm) in the catches was totally discarded. This was primarily due to the limited amount of freezer space available on vessels, which fishermen preferentially use to store high priced crustaceans. Conversely trawlers operating in coastal waters tend to reduce the discarded fraction to only the smallest specimens of the first age group present in the catches.

More recent data, collected within the framework of DCR, showed that the discarded fraction of undersized hakes by Sicilian trawlers is decreasing. In 2006, 54 tons of discards were recorded, which represented 13% in number and 3% in weight of total catch. In 2008, 46 tons of discards were reported, which again represented only 3% in weight of total catch.

The mean size of the discarded hakes varies according to the season. During 2006 the length at 50% discard of the Sicilian trawlers ranged between 12.9 (summer and autumn) and 15.0 (spring) cm TL, being 13.5 cm TL the yearly value (Gancitano V., pers. comm.).

5.10.2.3.3. Fishing effort

The trends in fishing effort by year and major gear type is listed in Table 5.10.2.3.3.1, and shown in Figure 5.10.2.3.3.1 in terms of kW*days for the bottom otter trawl fleet.

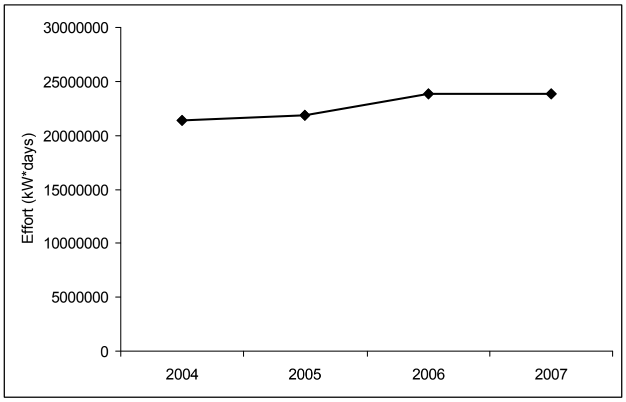


Fig. 5.10.2.3.3.1 Trend in annual effort (kW*days) of the Italian otter trawlers operating in GSAs 15 and 16, 2004-2007.

Tab. 5.10.2.3.3.1 Trend in annual effort (days at sea, GT*days, kW*days) by country and gears in GSAs 15 and 16, 2004-2007.

TYPE	AREA	COUNTRY	FT_LVL4	2004	2005	2006	2007
DAYS	15	MLT	[LHP] [LHM]		28		
DAYS	15	MLT	[SB] [SV]			73	59
DAYS	15	MLT	GNS		51		
DAYS	15	MLT	GTR		200	152	320
DAYS	15	MLT	LA			1116	1096
DAYS	15	MLT	LLD		3164	3159	2827
DAYS	15	MLT	LLS		1197	1466	1624
DAYS	15	MLT	LTL		263		
DAYS	15	MLT	OTB		421	404	688
DAYS	15	MLT	Other gear		64		
DAYS	15 & 16	ITA	DTS	81853	82557	89319	89164
DAYS	15 & 16	ITA	HOK	14856	11450	10272	9284
DAYS	15 & 16	ITA	PGP	118425	97285	85556	85298
DAYS	15 & 16	ITA	PMP	6939			
DAYS	15 & 16	ITA	PTS	4899	5476	7926	7032
GT*DAYS	15	MLT	[LHP] [LHM]		170		
GT*DAYS	15	MLT	[SB] [SV]			192	139
GT*DAYS	15	MLT	GNS		135		
GT*DAYS	15	MLT	GTR		1174	477	1023
GT*DAYS	15	MLT	LA			23999	29596
GT*DAYS	15	MLT	LLD		82011	72364	60606
GT*DAYS	15	MLT	LLS		16866	18866	18072
GT*DAYS	15	MLT	LTL		2539		
GT*DAYS	15	MLT	OTB		24878	34527	69268
GT*DAYS	15	MLT	Other gear		226		
GT*DAYS	15 & 16	ITA	DTS	6673029	6864030	7429483	7322198
GT*DAYS	15 & 16	ITA	HOK	764595	403669	507862	370612
GT*DAYS	15 & 16	ITA	PGP	249032	206056	192811	212519
GT*DAYS	15 & 16	ITA	PMP	20134			
GT*DAYS	15 & 16	ITA	PTS	224188	236435	352518	346405
KW*DAYS	15	MLT	[LHP] [LHM]		1880		
KW*DAYS	15	MLT	[SB] [SV]			3805	2507
KW*DAYS	15	MLT	GNS		2121		
KW*DAYS	15	MLT	GTR		13889	8391	20724
KW*DAYS	15	MLT	LA			203361	208456
KW*DAYS	15	MLT	LLD		554562	483437	449900
KW*DAYS	15	MLT	LLS		140846	159692	160914
KW*DAYS	15	MLT	LTL		26318		
KW*DAYS	15	MLT	OTB		129838	143909	240858
KW*DAYS	15	MLT	Other gear		3394		
KW*DAYS	15 & 16	ITA	DTS	21381964	21772464	23699835	23644626
KW*DAYS	15 & 16	ITA	HOK	3153486	1758722	2076446	1695903
KW*DAYS	15 & 16	ITA	PGP	2691324	2302777	2207660	2378933
KW*DAYS	15 & 16	ITA	PMP	223470			
KW*DAYS	15 & 16	ITA	PTS	962786	1063031	1592930	1431085
TSLDAYS	15 & 16	ITA	DTS				
TSLDAYS	15 & 16	ITA	PGP				
TSLDAYS	15 & 16	ITA	PMP				
TSLDAYS	15 & 16	ITA	PTS				

Tab. 5.10.2.3.3.2 Trend in annual effort (kW*days) by country and gears in GSAs 15 and 16 as reported through the DCF in 2010.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
15	MAL	FPO	DEMF		VL0006							4594
15	MAL	FPO	DEMF		VL0012						49249	
15	MAL	FPO	DEMF		VL0612							27061
15	MAL	FPO	DEMF		VL1224						1522	
15	MAL	GNS	DEMF		VL0012			1830			4379	
15	MAL	GNS	DEMF		VL1224			291				
15	MAL	GNS	DEMF	16D20	VL0006							346
15	MAL	GNS	DEMF	16D20	VL0612							1058
15	MAL	GNS	SLPF	16D20	VL0006							301
15	MAL	GNS	SLPF	16D20	VL0612							909
15	MAL	GTR	DEMF		VL0012			8364	6899	19700	14197	
15	MAL	GTR	DEMF		VL1224			5316	1492	1024	164	
15	MAL	GTR	DEMF		VL2440			209				
15	MAL	GTR	DEMF	16D20	VL0006							1222
15	MAL	GTR	DEMF	16D20	VL0612							2952
15	MAL	LA	SLPF		VL0012				54906	35688	46987	
15	MAL	LA	SLPF		VL0612							65405
15	MAL	LA	SLPF		VL1218							130081
15	MAL	LA	SLPF		VL1224				148455	160497	128657	
15	MAL	LA	SLPF		VL1824							34808
15	MAL	LA	SLPF		VL2440					12272		
15	MAL	LHM	CEP		VL0006							1729
15	MAL	LHM	CEP		VL0012						9497	
15	MAL	LHM	CEP		VL0612							2500
15	MAL	LHM	CEP		VL1224						298	
15	MAL	LHM	FINF		VL0012			5406			67	
15	MAL	LHM	FINF		VL1224			1352				
15	MAL	LHM	LPF		VL0012						9102	
15	MAL	LHM	LPF		VL1224						403	
15	MAL	LLD	LPF		VL0006							1971
15	MAL	LLD	LPF		VL0012			92350		107473	195062	
15	MAL	LLD	LPF		VL0612							202557
15	MAL	LLD	LPF		VL1218							199948
15	MAL	LLD	LPF		VL1224			420481		330062	299467	
15	MAL	LLD	LPF		VL1824							185676
15	MAL	LLD	LPF		VL2440			41731		12365	7811	41358
15	MAL	LLS	DEMF		VL0006							5242
15	MAL	LLS	DEMF		VL0012			47773	82092	81472	141656	
15	MAL	LLS	DEMF		VL0612							101973
15	MAL	LLS	DEMF		VL1218							40027
15	MAL	LLS	DEMF		VL1224			79870	73824	79442	68490	
15	MAL	LLS	DEMF		VL1824							8556
15	MAL	LLS	DEMF		VL2440			13204	3775			634
15	MAL	LTL	LPF		VL0006							1179
15	MAL	LTL	LPF		VL0012			13009	8073			
15	MAL	LTL	LPF		VL0612							3270
15	MAL	LTL	LPF		VL1224			13100	2137			
15	MAL	LTL	LPF		VL2440			209				
15	MAL	OTB	MDDWSP		VL1224			128047	133167	201767	352184	
15	MAL	OTB	MDDWSP		VL2440			1790	10742	39090	30358	
15	MAL	OTB	MDDWSP	40SXX	VL1824							340113
15	MAL	OTB	MDDWSP	40SXX	VL2440							59792
15	MAL	PS	LPF		VL2440						13920	
15	MAL	PS	LPF	14D16	VL2440							15442
15	MAL	PS	SPF		VL0012						6490	
15	MAL	PS	SPF		VL1224						35413	
15	MAL	PS	SPF	14D16	VL0612							373
15	MAL	PS	SPF	14D16	VL1218							14890
15	MAL	PS	SPF	14D16	VL1824							14920
15	MAL	SB-SV	DEMF		VL0006							286
15	MAL	SB-SV	DEMF		VL0012					2343	1334	
15	MAL	SB-SV	DEMF		VL0612							679
15	MAL	SB-SV	DEMF		VL1224					164		
15	MAL	TBB	DEMF		VL0012						493	
15	MAL	TBB	DEMF		VL0612							82
15	MAL	TBB	DEMF		VL1224						1292	
16	ITA				VL0612			3886			417	
16	ITA	GTR	DEMSP		VL0006				8548	9979	12285	
16	ITA	GTR	DEMSP		VL0612		164944	178522	76073	103953	103352	
16	ITA	GTR	DEMSP		VL1218		25926	7720	23894	18868	8189	
16	ITA	GTR	DEMSP		VL1824			1420				
16	ITA	LHP-LHM	CEP		VL0006				525	1162		
16	ITA	LHP-LHM	FINF		VL0612		16931	16553	14973	15019	21934	
16	ITA	LHP-LHM	FINF		VL1218		641					
16	ITA	LLD	LPF		VL1218		12401	3900	2924	3435	16936	
16	ITA	LLD	LPF		VL1824		36304	5756	1029	78320	12919	
16	ITA	LLS	DEMF		VL0006				1022	3942	1394	
16	ITA	LLS	DEMF		VL0612		26733	58661	12698	57631	9512	
16	ITA	LLS	DEMF		VL1218		21984	1640	3115	62773	18439	
16	ITA	LLS	DEMF		VL1824		1870					
16	ITA	OTB	DEMSP		VL1218		210042	238629	272220		263191	
16	ITA	OTB	DEMSP		VL1824		54367	13425			397440	
16	ITA	OTB	DEMSP		VL2440						693213	
16	ITA	OTB	DWSP		VL1824						15246	
16	ITA	OTB	DWSP		VL2440						41113	
16	ITA	OTB	MDDWSP		VL1218					285378	4336	
16	ITA	OTB	MDDWSP		VL1824		377936	418914	434834	549867	93949	
16	ITA	OTB	MDDWSP		VL2440		1116269	1161841	442196	1484331	225904	
16	ITA	OTM	MDPSP		VL1824				21611	26555	41792	
16	ITA	OTM	MDPSP		VL2440		5306		9096			
16	ITA	PS	LPF		VL1824						9763	
16	ITA	PS	SPF		VL0006						397	
16	ITA	PS	SPF		VL0612			8471		670	3127	
16	ITA	PS	SPF		VL1218		1772	1997	1355		2354	
16	ITA	PS	SPF		VL1824		17339	12429	7349	39307	11625	
16	ITA	PTM	SPF		VL1824			19612	72116	107330	38857	

5.10.3. Scientific surveys

5.10.3.1. Medits

5.10.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were recalculated. In order to collect fisheries independent data, which is a requirement of the EU DCF (Council Regulation 199/2008, Commission Regulation 665/2008, Commission Decision EC 949/2008 and Commission Decision 93/2010), the MEDITS international trawl survey is carried out in GSA 16 on an annual basis. The following number of hauls was reported per depth stratum in 1994- 2009:

Tab. 5.10.3.1.1.1 Number of hauls per year and depth stratum in GSA 15 and 16, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA15_010-050									1	2	4	1	1			
GSA15_050-100									6	9	7	5	5	12	6	6
GSA15_100-200									12	23	23	13	13	12	12	15
GSA15_200-500									9	18	16	9	9	4	9	10
GSA15_500-800									18	28	27	17	16	17	17	15
GSA16_010-050	4	4	4	4	4	4	4	4	7	7	7	10	10	11	11	11
GSA16_050-100	9	8	8	8	8	8	7	8	11	12	12	20	22	23	23	23
GSA16_100-200	4	4	4	4	5	5	6	5	11	10	11	20	19	21	21	21
GSA16_200-500	10	11	11	12	11	11	11	11	19	18	26	37	31	27	27	27
GSA16_500-800	10	14	14	13	14	14	14	14	20	20	21	33	33	38	38	38

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.10.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.10.3.1.3. Trends in abundance and biomass

In addition to information on the trends in hake abundanc estimated through the MEDITS survey, fisheries independent information was also collected in GSA 16 through the GRUND survey, which is conducted in autumn (Fig. 5.10.3.1.3.1). The biomass indices of both surveys show very similar patterns, with a stable period from 2000-2003, followed by a sharp increase in biomass in 2004-2006 and a decline to intermediate levels in 2007-2009.

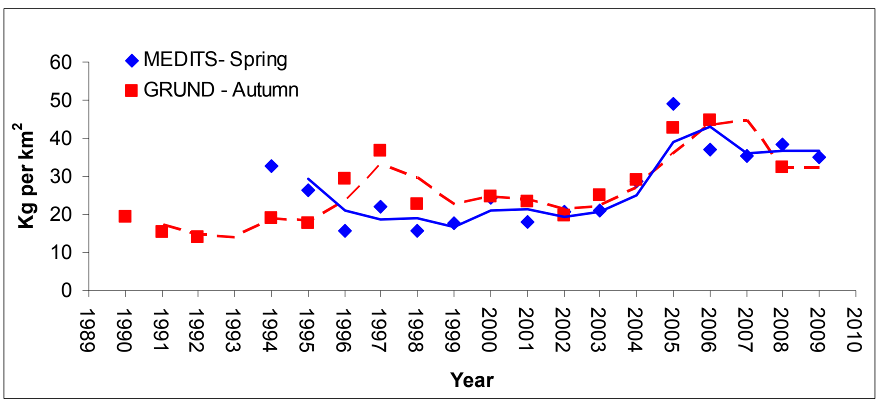


Fig. 5.10.3.1.3.1 Biomass indices (Kg·Km^{-2}) obtained during the MEDITS and GRUND surveys in GSA 16.

The trend in abundance and biomass, including upper and lower 95% confidence intervals as re-estimated by SGMED-10-02 are shown in Figure 5.10.3.1.3.2 for GSAs 15 and 16, respectively.

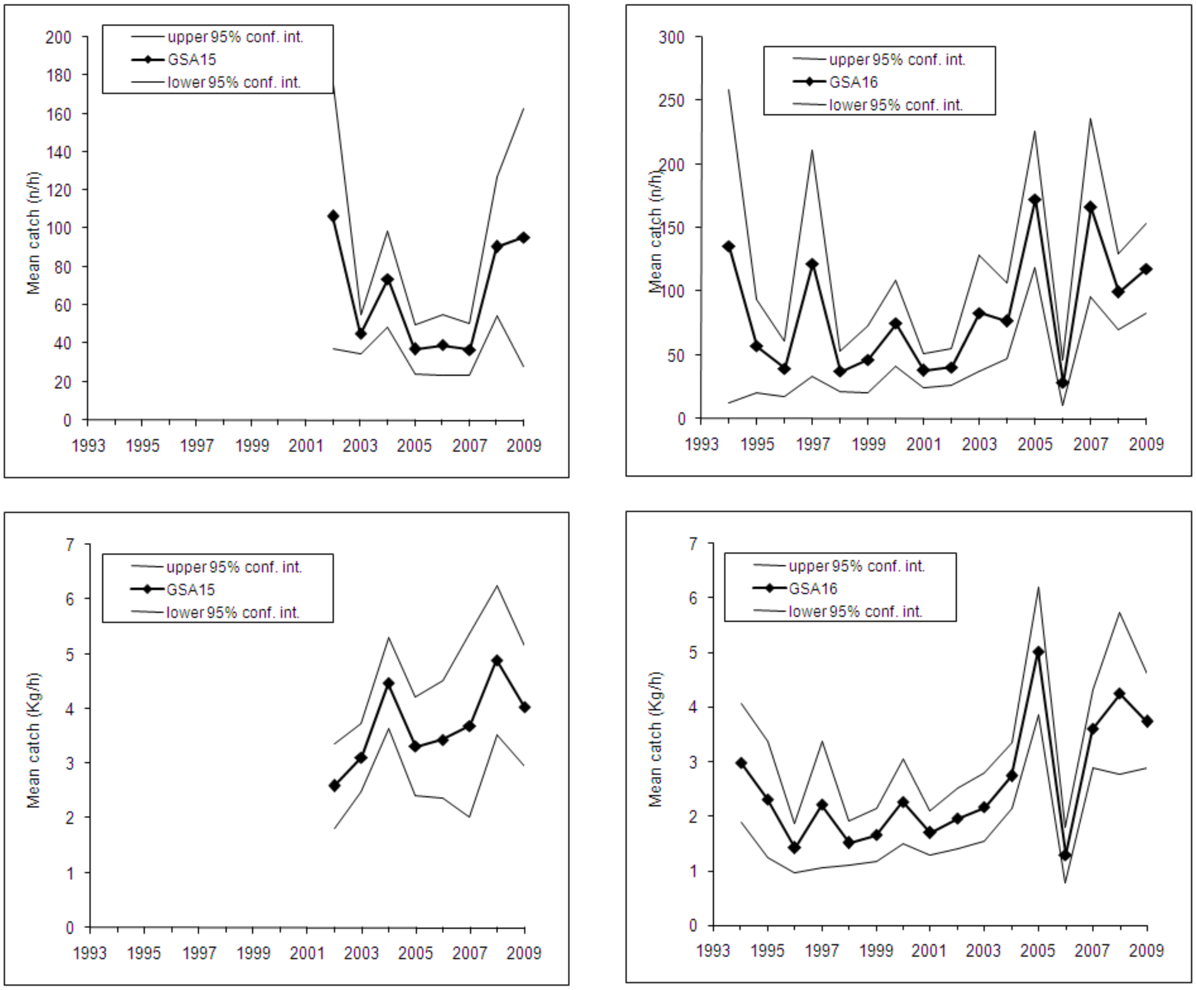


Fig. 5.10.3.1.3.2 Abundance and biomass indices of hake in GSA 15 and GSA 16.

5.10.3.1.4. Trends in abundance by length or age

The Figure 5.10.3.1.4.1 displays the stratified abundance indices of GSA 15 in 2002-2009.

The Figures 5.10.3.1.4.2 and 5.10.3.1.4.3 display the stratified abundance indices of GSA 16 in 1994-2001 and 2002-2009.

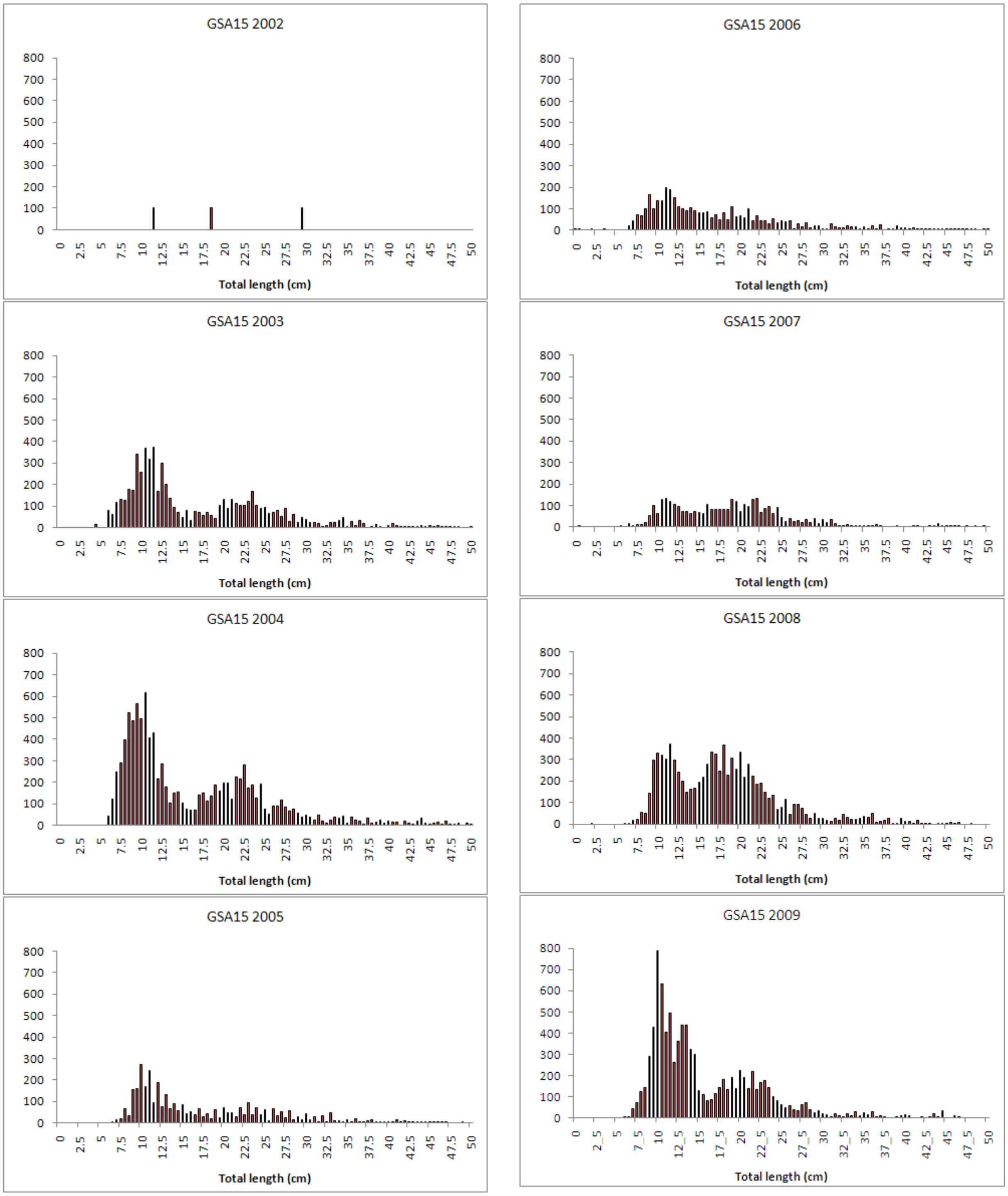


Fig. 5.10.3.1.4.1 Stratified abundance indices by size in GSA 15, 2002-2009.

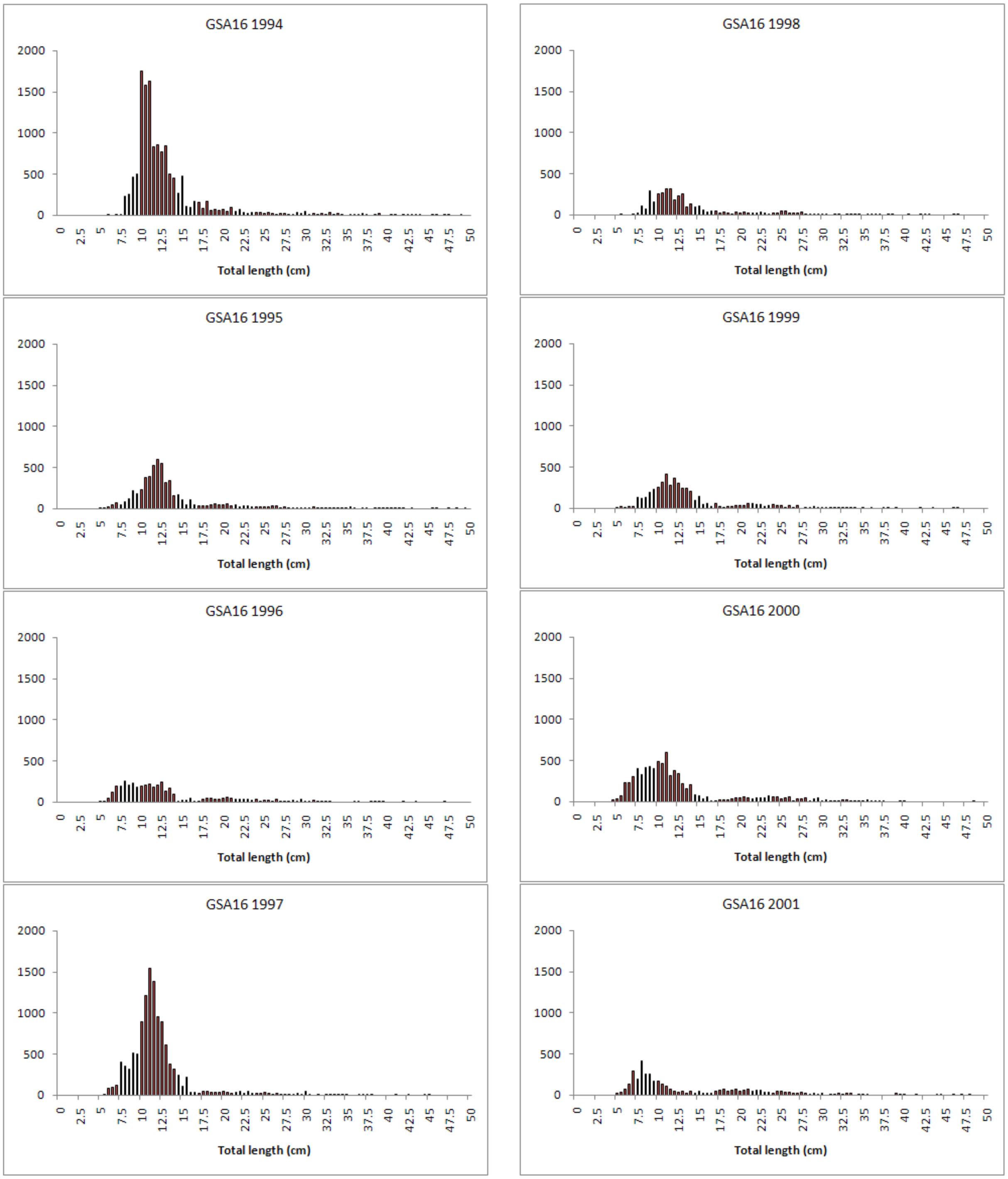


Fig. 5.10.3.1.4.2 Stratified abundance indices by size in GSA 16, 1994-2001.

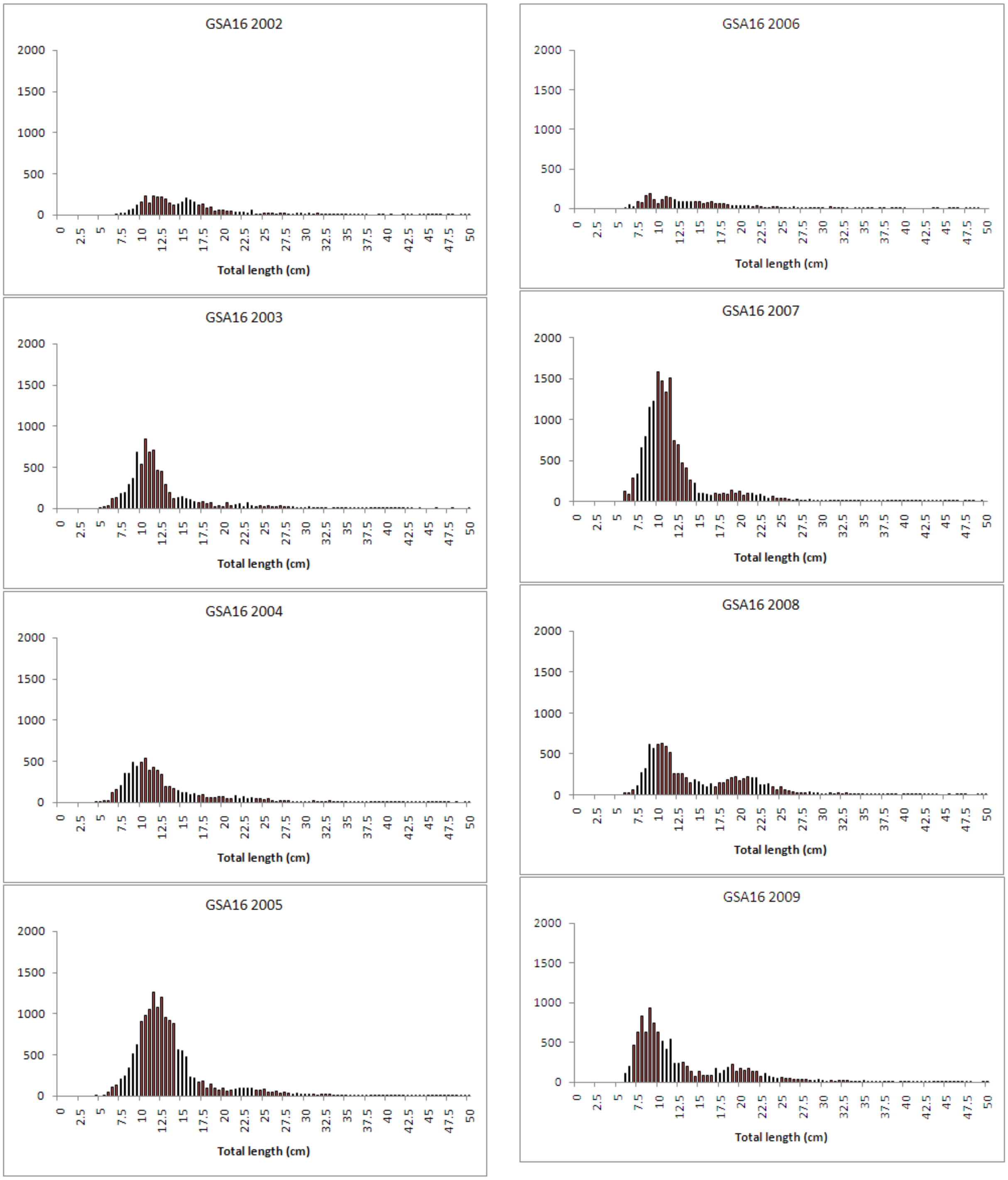


Fig. 5.10.3.1.4.3 Stratified abundance indices by size in GSA 16, 2002-2009.

5.10.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.10.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.10.4. Assessment of historic stock parameters

5.10.4.1. Method 1: SURBA

5.10.4.1.1. Justification

The availability of a long time series (1994-2009) of length frequency distributions (LFD) from trawl survey data allowed the reconstruction of the evolution of hake fishing mortality rates in GSA 16 by using the SURBA software package. Firstly the LFD by sex from the MEDITS trawl surveys was corrected by including the data for the individuals with unidentified sexes. This was based on the sex ratio per size class. The corrected LFDs by sex for each GSA were then converted in numbers by age group using the subroutine "age slicing" as implemented in the software package LFDA (Kirkwood *et al*., 2001). Secondly we estimated the mean weight at age using the VBGF and a vectorial natural mortality at age using Probiom (Caddy and Abella, 1999).

5.10.4.1.2. Input parameters

The von Bertalanffy growth function (VBGF) parameters used for age slicing of the *M. merluccius* LFD were calculated by taking averages of male and female parameters (obtained from CNR-IAMC (2007) for GSA 16), which were subsequently weighed by estimated the sex ratio. The combined stock parameters were: L_{inf}= 100cm; k= 0.116; t_0= -0.643; a= 0.0043; b= 3.1525.

Tab. 5.10.4.1.2.1 GSA 16 MEDITS hake LFD, values shown are standardized to n/km^2.

Size (cm)	1994	1995	1996	1997	1998	1999	2000	2001
=12	87372	33715	20655	71141	22735	27983	50687	18550
14	12349	5609	1336	7985	4232	4507	4203	939
16	5744	2565	1436	1418	1968	1692	1110	1286
18	3694	2389	1775	1764	978	803	1512	2205
20	2674	2489	2340	1995	969	1846	1812	2191
22	2090	1315	1452	1815	699	1440	2130	1950
24	2098	1076	1045	1295	1120	1416	1948	1502
26	780	1461	549	726	951	738	1380	1156
28	791	706	929	647	355	493	1344	635
30	777	484	609	545	311	350	628	495
32	626	457	233	172	258	382	478	534
34	494	465	0	288	191	247	513	297
36	473	347	109	229	113	64	282	0
38	361	276	149	43	234	65	82	224
40	191	160	0	125	43	0	60	44
42	121	64	45	23	134	67	0	0
44	91	56	0	65	0	0	0	45
46	89	44	23	0	98	44	0	45
48	28	42	0	0	0	0	21	44
50	0	56	0	0	21	0	0	0
52	62	0	23	0	0	22	48	22
54	0	0	46	0	0	46	0	22
56	29	21	26	0	0	0	22	0
58	62	0	22	0	28	0	60	46
60	0	0	0	0	0	0	0	0
62	0	21	0	0	0	0	0	0
64	0	0	0	0	0	23	0	0
66	0	22	0	0	0	22	0	0

Size (cm)	2002	2003	2004	2005	2006	2007	2008	2009
=12	17816	59964	35774	105245	88004	126111	53449	81661
14	6577	5684	6935	27417	6153	7444	6453	4328
16	6873	3313	4074	9312	5439	3412	4926	4165
18	3120	1875	2525	4746	6163	3907	7056	6329
20	2140	1453	2797	3360	5337	3857	7609	5739
22	1334	1576	2667	4112	4264	2857	5427	3750
24	592	905	1949	2947	2770	2159	3076	1983
26	792	775	976	2043	1860	971	1445	1508
28	541	526	604	1088	873	637	1097	1099
30	384	444	480	760	545	457	519	742
32	351	186	336	529	403	293	616	558
34	221	223	255	326	317	270	301	495
36	305	195	229	264	230	208	310	292
38	50	136	138	157	143	135	171	154
40	29	174	105	265	153	110	93	92
42	44	66	93	138	54	162	130	120
44	147	15	87	167	53	107	41	80
46	62	29	81	75	55	66	50	110
48	78	14	28	71	0	67	32	51
50	16	51	62	38	45	45	36	47
52	14	0	56	0	19	16	16	24
54	67	29	29	48	19	8	24	33
56	15	0	0	27	17	41	37	20
58	14	0	0	41	9	25	27	0
60	0	15	14	0	28	18	16	0
62	0	0	14	38	8	0	16	0
64	0	0	30	0	17	8	36	0
66	0	0	59	28	27	8	0	0

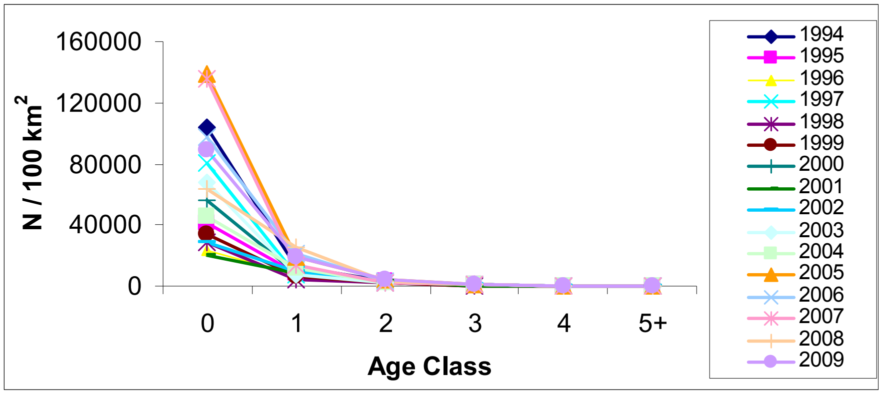


Fig. 5.10.4.1.2.1. GSA 16 hake age frequency distributions for 1994-2009, obtained from age slicing using combined sex parameters.

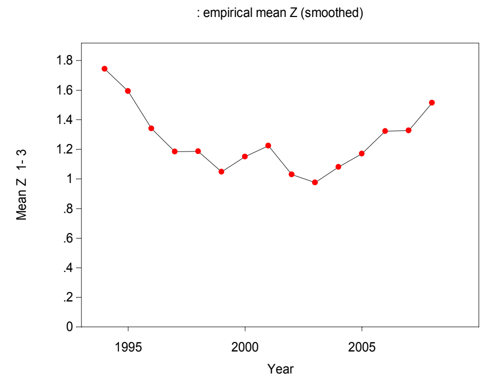
Natural mortality rates by age group, constant for all years, were calculated based on ProdBiom (Abella *et al.*, 1997), as recommended by SGMED 09-01. Guess estimates of catchability by age were used.

Tab. 5.10.4.1.2.2. Vectors of natural mortality, maturity, weight and catchability for hake (sex combined) in the Strait of Sicily (GSA 16).

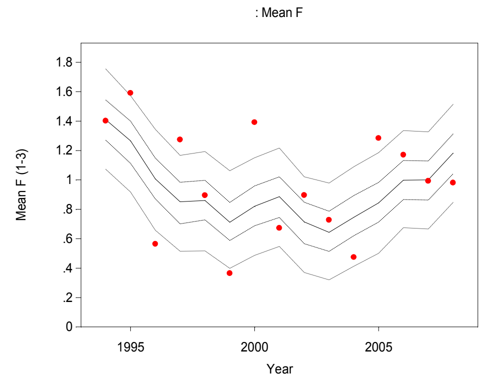
	Age					
	0.5	**1.5**	**2.5**	**3.5**	**4.5**	**5.5**
Mortality	0.68	0.30	0.22	0.19	0.17	0.16
Weight	12.08	73.40	206.35	415.86	696.04	1035.30
Catchability	0.8	1	1	1	0.75	0.5

5.10.4.1.3. Results

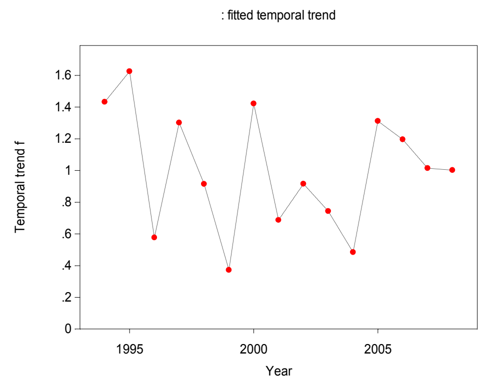
SURBA outputs show that in 2005-2008 mean F for the age groups 1-3 years old fish decreased from 1.28 to 0.98 and increased thereafter. Relative SSB has remained at an approximately stable level since 2006.



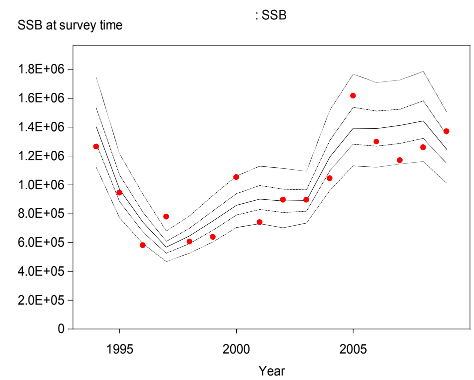
A)



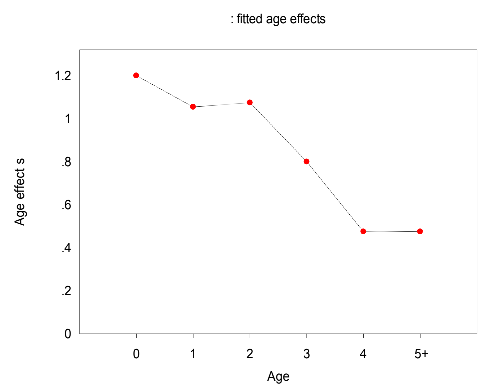
D)



B)



E)



C)

Fig. 5.10.4.1.3.1 Results of SURBA analysis based on 1994-2009 MEDITS hake survey data from GSA 16. A) Smoothed empirical mean Z, ages 1-3; B) Fitted temporal trend in F; C) Fitted age effect in F; D) Mean F; E) SSB at survey time. 50th percentile of bootstrapped runs (solid line) and 5% and 95% percentiles of bootsrapped runs (dashed lines) are shown for D) and E).

The recruitment indices obtained during MEDITS surveys (Fig. 5.10.4.1.3.2) ranged between 85 and 577 individuals per km^2. After a period of low recruit abundance from 1995 to 2002, a phase of increasing recruitment is occurring.

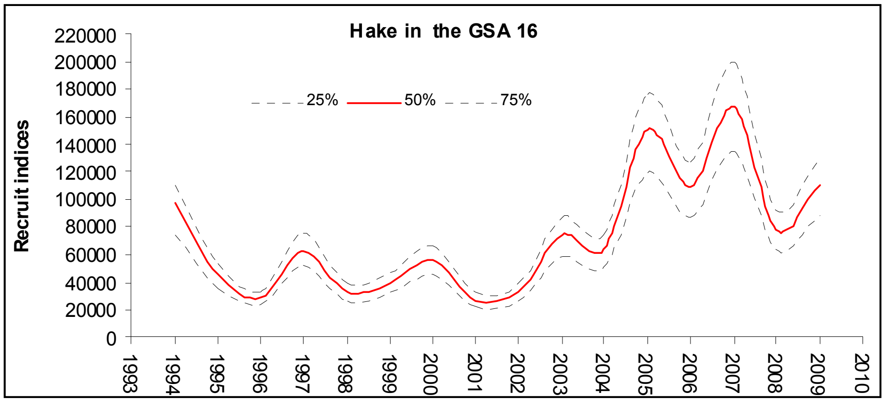
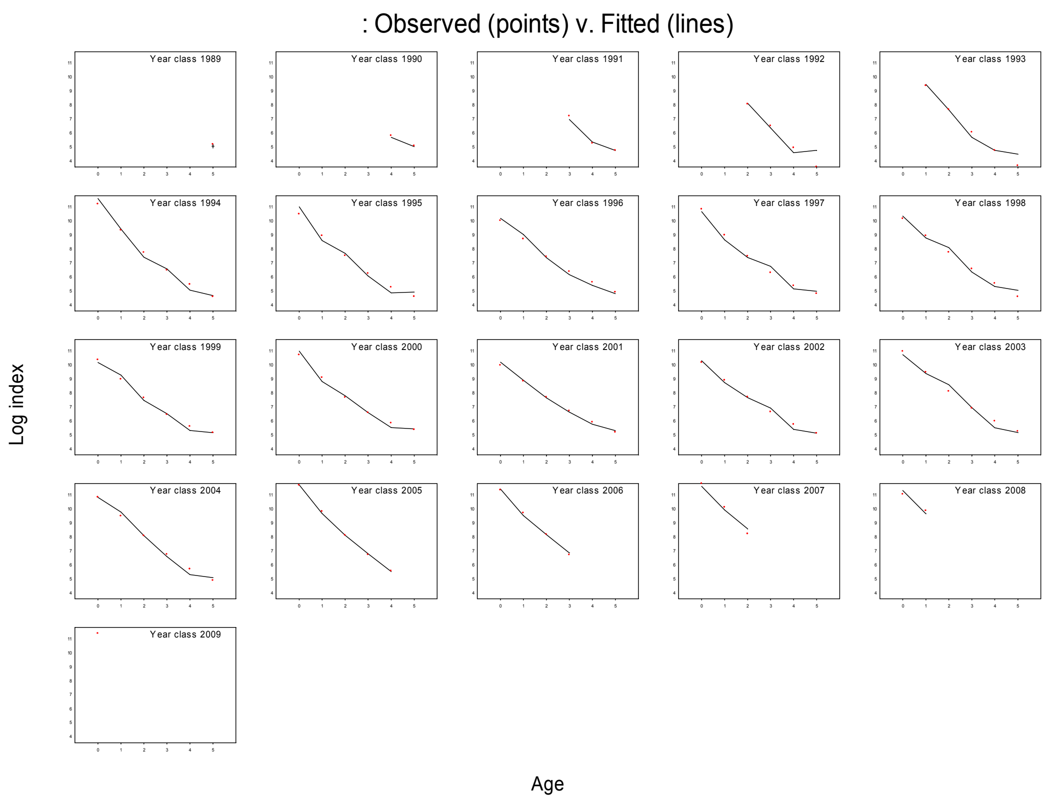
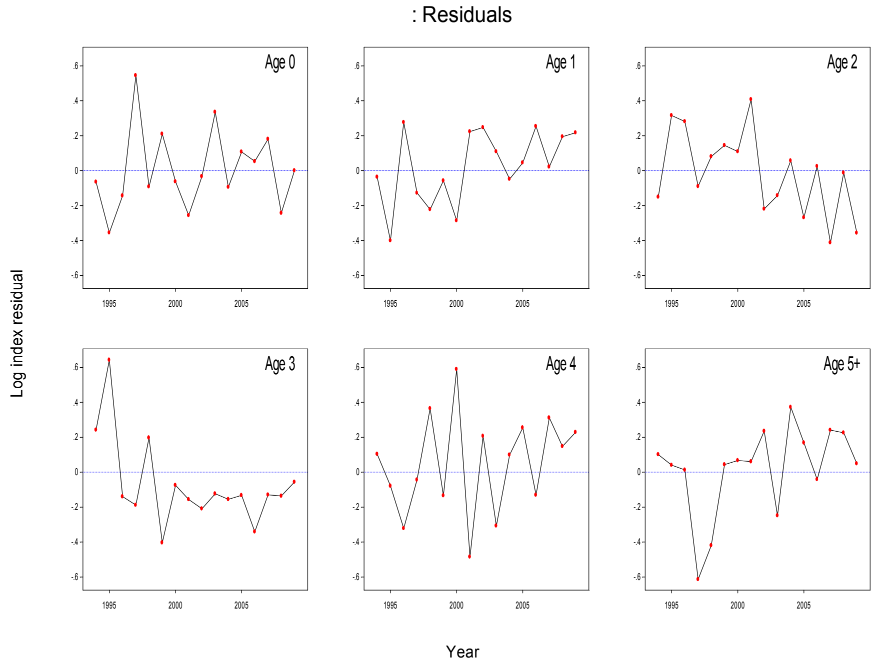


Fig. 5.10.4.1.3.2 Recruitment indices (MEDITS surveys) in GSA 16 from SURBA; 25th, 50th and 75th percentiles of bootstrapped runs are reported.

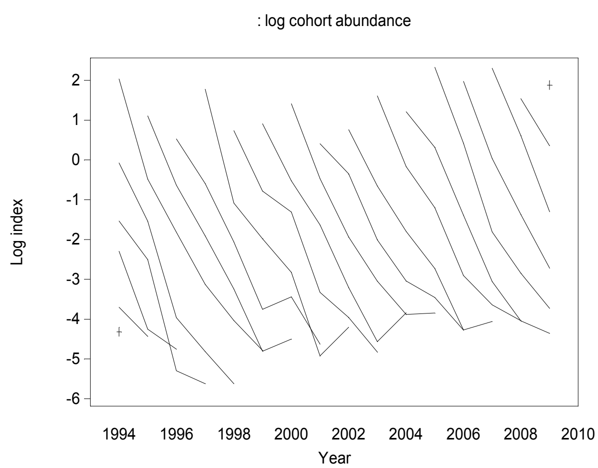
Model diagnostics are shown below.



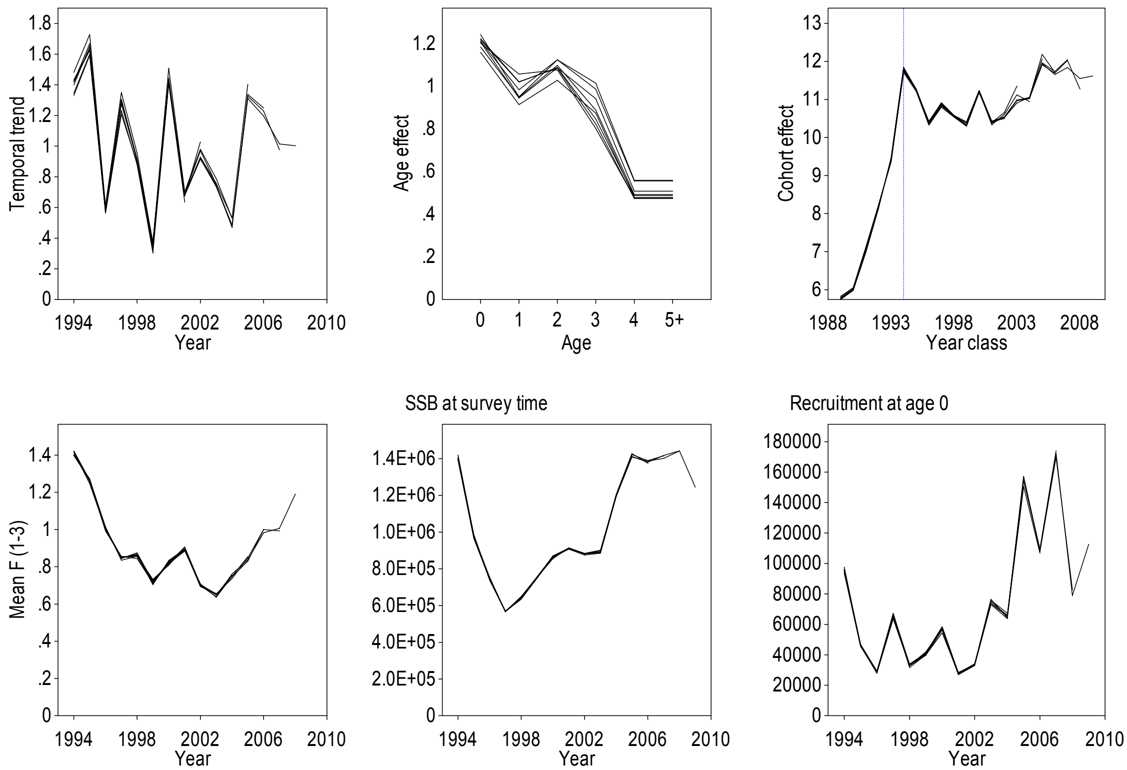
A)


: Residuals
Age 0
Age 1
Age 2
Age 3
Age 4
Age 5+
Log index residual
Year

B)


: log cohort abundance
Log index
Year

C)



D)

Fig. 5.10.4.1.3.3 Model diagnostic for SURBA analysis based on 1994-2009 MEDITS hake survey data from GSA 16. A) Comparison between observed (points) and fitted (lines) of MEDITS survey abundance indices, for each year; B) Log index residuals over time, plotted by age class; C) Log survey abundance indices by cohort, where each line represents the log index abundance of a particular cohort throughout its life; D) Retrospective SURBA model outputs.

5.10.4.2. Method 2: VIT

5.10.4.2.1. Justification

Since only three complete years (2006, 2007 and 2008) of length frequency distributions from commercial landings data were available, an approach under steady state (pseudocohort) was used. Pseudocohort and Y/R analysis as implemented in the package VIT4win were used (Lleonart and Salat, 2000). Data were derived from the DCF official data call for GSA 16.

5.10.4.2.2. Input parameters

LFD from commercial landings were converted into numbers at age using combined sex stock parameters calculated as described for MEDITS input parameters above. The combined stock parameters used were: L_{inf} = 100cm; k = 0.116; t_0 = -0.643; a = 0.0043; b = 3.1525. The maturity and natural mortality vector by size are reported in Table 5.10.4.2.1.1. Terminal F was fixed as 0.20. Discard data was not included in the analysis.

Table 5.10.4.2.1.1 Maturity and natural mortality vector by size (combined sex).

TL (cm)	% of mature	M	TL (cm)	% of mature	M
12	0.02	1.93	44	0.86	0.22
14	0.02	1.37	46	0.92	0.22
16	0.04	0.96	48	0.96	0.20
18	0.06	0.74	50	0.97	0.20
20	0.09	0.61	52	0.98	0.19
22	0.13	0.52	54	0.99	0.19
24	0.16	0.45	56	1.00	0.18
26	0.23	0.40	58	1.00	0.18
28	0.31	0.36	60	1.00	0.17
30	0.35	0.33	62	1.00	0.15
32	0.44	0.30	64	1.00	0.15
34	0.46	0.28	66	1.00	0.14
36	0.48	0.26	68	1.00	0.14
38	0.63	0.25	70	1.00	0.13
40	0.68	0.24	72	1.00	0.13
42	0.80	0.23	74	1.00	0.12

Tab. 5.10.4.2.1.2 LFD of commercial hake landings data from GSA 16 by fleet segment used as input data for age slicing and subsequently VIT analysis.

	Trawlers 12-24m			Trawlers > 24m		
Length (cm)	2006	2007	2008	2006	2007	2008
12	288894	606773	235866	818	0	1051
14	2938474	2850866	1960737	104585	21131	77341
16	3929216	3254704	2663705	1006712	517323	514682
18	3301003	3462604	2930002	1396832	1178380	917213
20	2307962	2250072	2170930	1071935	1433477	885288
22	1672636	1482702	1486808	795064	1009861	710617
24	969605	798260	899731	538323	622539	470202
26	519955	450890	507442	262833	293750	279173
28	341680	231243	281328	163372	177918	181226
30	191177	152939	150609	137456	131570	132351
32	99707	129260	113993	98089	104978	95220
34	73973	71932	75438	61857	50854	61606
36	57725	47007	61857	44070	37176	63671
38	18836	25915	31445	41075	25656	37993
40	8768	26689	26888	26465	34543	24181
42	15842	6622	20369	19974	17675	10254
44	5168	6081	11656	10955	12436	6969
46	6466	5072	12333	5183	15896	6303
48	8653	8915	7569	7028	10052	5600
50	6500	5735	540	3982	15602	3500
52	4000	6595	1882	13287	9698	3000
54	2450	6901	1258	879	2393	1094
56	3161	2523	634	5840	2500	2442
58	2259	1080	1191	2800	2000	2442
60	2000	5230	1498	900	1800	876
62	1000	3069	1584	835	1600	1624
64	3161	2000	1669	1860	1000	0
66	0	1540	864	0	0	0
68	0	1080	0	0	0	0

5.10.4.2.3. Results

Fishing mortality rates (F) for combined sexes by age class, fleet segment and year are shown in Fig. 5.10.4.2.3.1.

A)

B)

C)

Fig. 5.10.4.2.3.1 Fishing mortalities rates (F) by age and fleet segment for combined sexes of hake in GSA 16. A) 2006; B) 2007; C) 2008.

The reconstructed yields obtained by the VIT package for 2006, 2007 and 2008 (1597.43, 1599.29, 1367.86 t) were virtually equal to the observed yields (1598, 1599 and 1367 t). The other main results of the VIT analysis, including the current mortality rates, are listed in Table 5.10.4.2.3.1.

Table 5.10.4.2.3.1 The main results of VIT analysis.

Variables	2006	2007	2008
Observed Yield (tons)	1598	1599	1367
Reconstructed Yield (tons)	1597.43	1599.29	1367.86
Mean F	0.60	0.58	0.65
Mean Z (ages 1-3)	1.42	1.38	1.50
Mean F (ages 1-3)	1.19	1.15	1.26
Catch mean length (cm)	19.54	19.54	20.22
Stock mean length (cm)	14.85	14.89	14.90

5.10.4.3. Method 2: Non equilibrium Surplus Production model

5.10.4.3.1. Justification

When commercial information is limited, but a long time-series of Z and U from trawl surveys are available, a variant of a non-equilibrium surplus production model can be fitted (Abella, 2007).

The classical model requiring time series of index of abundance and effort is:

$$B_{t+1} = B_t + rB_t(1-(B_t / k)) - qfB_t$$

Since $qfBt = Y$, catch in weight (Yt) can be substituted by the classic Baranov catch equation:

$$Y=(F/Z)\ B(1-exp(-Z_t)$$

and the model can now be written as:

$$B_{t+1} = B_t + rB_t(1-(B_t / k)) – (F/Z)\ B_t(1-exp(-Z_t)\ )$$

Z can be estimated by analysing the size structure of the surveys catches, and F computed by subtraction if an estimate of M is available.

5.10.4.3.2. Input parameters

Data input is time series of biomass indices and total mortality rates derived from MEDITS trawl surveys in GSA 16 (1994-2009). A scalar value of M=0.34 was used to estimate Z_{MBP} from F_{MBP}.

Tab. 5.10.4.3.2.1 Non equilibrium surplus production model data inputs. BI are overall means in kg/km^2 and total mortality rates are SURBA estimates.

Year	Z	BI	Year	Z	BI
1994	1.74	32.63	**2002**	1.03	20.59
1995	1.59	26.36	**2003**	0.98	21.06
1996	1.34	15.61	**2004**	1.08	28.83
1997	1.18	21.89	**2005**	1.17	49.13
1998	1.19	15.82	**2006**	1.32	37.05
1999	1.05	17.77	**2007**	1.33	35.19
2000	1.15	24.46	**2008**	1.51	38.43
2001	1.22	18.01	**2009**	n/a	35.04

5.10.4.3.3. Results

Main model parameters are reported in Table 5.10.4.3.3.1.

Tab. 5.10.4.3.3.1 Main parameters of the surplus production model of hake in GSA 16.

Population growth rate (r)	0.82
K	68.3
F_{MBP} (r/2)	0.41
Z_{MBP} (F_{MBP}+M)	0.75

Observed and predicted values of biomass indices (kg per km^2) were in agreement (Fig. 5.10.4.3.3.1), and the distribution of residuals was satisfying (Fig. 5.10.4.3.3.2). The surplus production model in terms of Biological production is shown in Fig. 5.10.4.3.3.3.

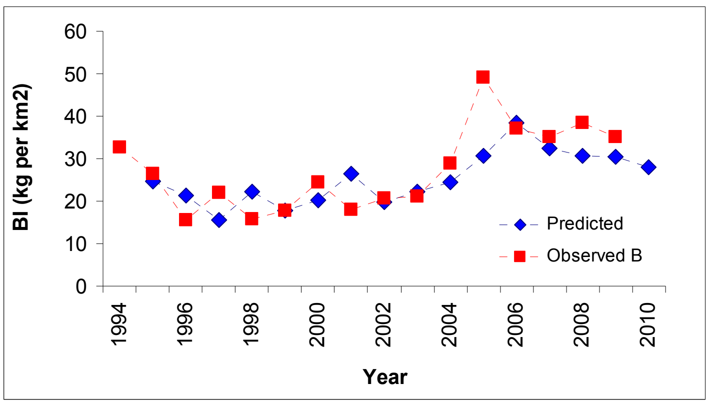


Fig. 5.10.4.3.3.1 Observed and predicted values of biomass indices (kg/km^2) according to the Surplus production model based on hake trawl survey data from GSA 16.

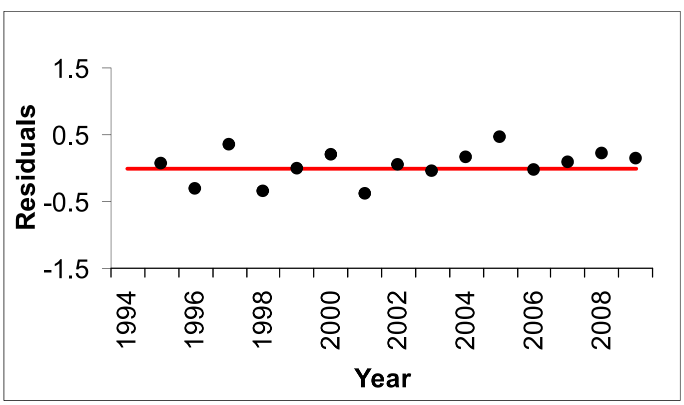


Fig. 5.10.4.3.3.2 Residuals of fitted non-equilibrium surplus production model.

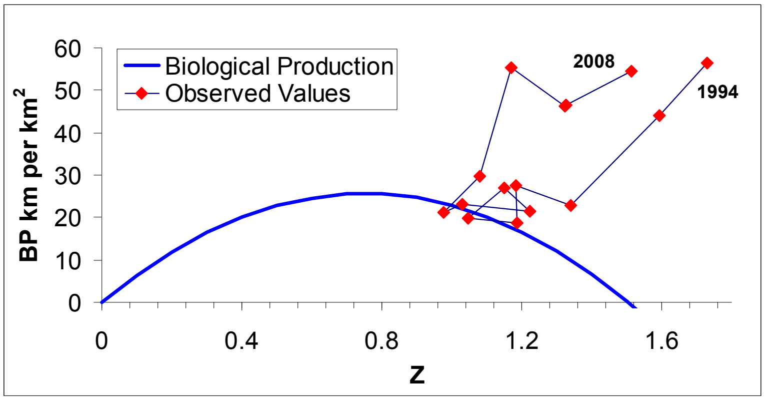


Fig. 5.10.4.3.3.3 Biological production (BP) vs. total mortality rates (Z) for hake in GSA 16 under the non-equilibrium state assumption.

The ratio of the mean Z of 2007 and 2008 obtained by SURBA (Z= 1.421) and the optimal one (Z_{MBP}= 0.752) suggested an overfishing state ($Z_{curr.}/Z_{opt.}$=1.89). If an estimation of current F is obtained as Z-M, with M=0.34, the ratio between current F (1.081) and the optimal one (F_{MBP}=0.412) suggested a reduction of fishing mortality of 62% to improve the status of the stock.

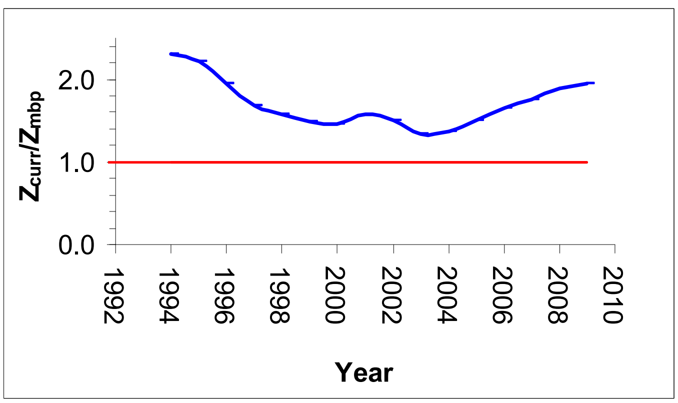


Fig. 5.10.4.3.3.4 Ratio of current total mortality rates (Z_{curr}) over total mortality rates which would sustain maximum biological production (Z_{mbp}).

5.10.5. Long term prediction

5.10.5.1. Justification

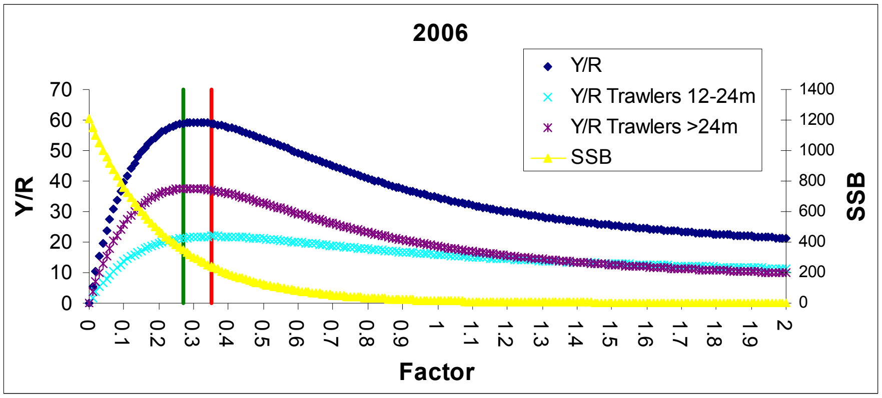
The VIT approach to biomass and yield per recruit analysis has been applied in order to analyse the stock production with increasing exploitation under equilibrium conditions.

5.10.5.2. Input parameters

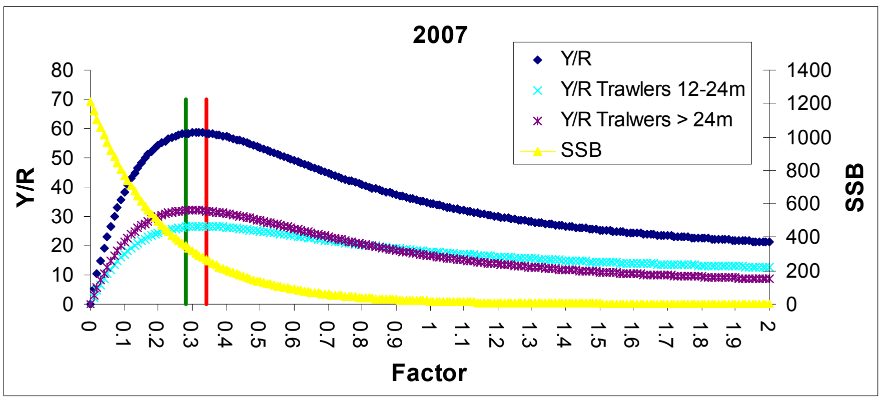
The input parameters have been already reported in section 5.10.4.3.2.

5.10.5.3. Results

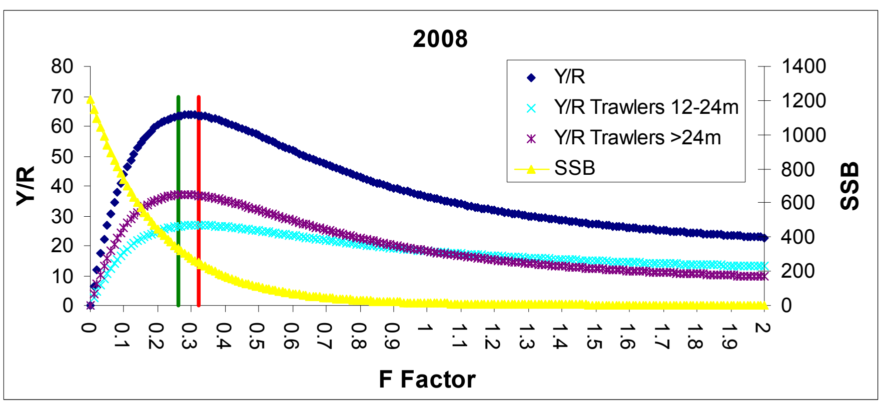
The results of estimating spawning stock biomass as well as biomass and yield per recruit, by varying current fishing mortality (Fc) through a multiplicative factor for 2006, 2007 and 2008 catches, are reported in Fig. 5.10.5.3.1 A) - C).



A)



B)



C)

Fig. 5.10.5.3.1 Spawning Stock Biomass and Yield per recruit under varying current fishing mortality (Fc) according to the VIT package. Green lines indicate $F_{0.1}$, red lines F_{max}. A) 2006; B) 2007; C) 2008.

Assuming no variation in the exploitation pattern, the main results of Y/R analysis are reported in Tab. 5.10.5.3.1.

Tab. 5.10.5.3.1 Estimation of yield (Y in g), biomass (B in g) and spawning stock biomass (SSB in g) per recruit (R) varying current fishing mortality by a multiplicative factor.

	Variable	Factor	Y/R	B/R	SSB
2006	F(Virgin)	0.00	0.00	1365.68	1209.06
	F(0.1)	0.27	58.53	440.26	358.47
	F(max)	0.35	59.02	331.43	261.33
	F(Current)	1.01	34.55	40.46	16.56
	F(Double)	2.00	21.22	13.25	1.49
2007	F(Virgin)	0.00	0.00	1365.68	1209.06
	F(0.1)	0.28	57.76	447.16	365.71
	F(max)	0.34	58.58	356.96	284.99
	F(Current)	1.01	34.50	42.25	18.40
	F(Double)	2.00	21.18	13.21	1.52
2008	F(Virgin)	0.00	0.00	1365.68	1209.06
	F(0.1)	0.26	62.70	440.63	355.58
	F(max)	0.32	63.65	345.84	270.61
	F(Current)	1.01	36.36	39.34	13.98
	F(Double)	2.00	22.73	14.55	1.65

According to the VIT steady state VPA, a state of overfishing for all three years was clearly detected. Maintaining the current fishing pattern, an average reduction of current effort of 73% and 66% is advisable to reach $F_{0.1}$ and F_{max} respectively.

5.10.6. Data Quality and Availability

SGMED 10-02 noted that data from GSA 15 was not submitted in accordance with the deadline and thus was not be included in the assessments. Whilst data from commercial catches declared in GSA 16 are representative for the entire area, the lack of scientific survey data from GSA 15 did impact the overall quality of the assessment as the hake population is distributed throughout both GSA 15 and GSA 16. Landings data from 2009 were not submitted by the Italian authorities,, which implies that the assessment based on commercial catches could only be carried out for years 2006, 2007 and 2008. SGMED 10-02 noted an error in the GSA 16 effort data in terms of KW * Days reported for otter board trawlers measuring > 24m in length, as well as in effort data in terms of days at sea.

5.10.7. Scientific advice

5.10.7.1. Short term considerations

5.10.7.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.10.7.1.2. State of recruitment

MEDITS results indicate that levels of recruitment peaked in 2005-2007, followed by a decline in 2008 and 2009.

5.10.7.1.3. State of exploitation

Results of analyses performed on fisheries dependent as well as fisheries independent data using different modelling approaches gave consistent results. All approaches indicated that fishing mortality is far in excess of sustainable levels, and that *Merluccius merluccius* in GSA 16 was overexploited during the years 2006, 2007 and 2008. The continued low abundance of adult fish in the surveyed population as well as commercial catches similarly indicate very high exploitation patterns far in excess of fishing mortalities consistent with sustainable high yields.

Tab. 5.10.7.1.3.1 Summary table of assessment outcomes for combined sex analysis of hake in GSA 16.

Method	**Year**	**2006**	**2007**	**2008**
VIT	Factor for F0.1	0.27	0.28	0.26
VIT	Factor For Fmax	0.35	0.34	0.32
VIT	Mean F	0.60	0.58	0.65
VIT	Mean F 1-3	1.19	1.15	1.26
SURBA	Mean F 1-3	1.01	1.00	1.16
SURBA / Production	Z MBP / FMBP	0.752 / 0.412		
VIT	Mean Z 1-3	1.42	1.38	1.50
SURBA	Mean Z	1.32	1.33	1.51

SGMED recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Based on the biological reference points calculated using VIT and the SURBA/non-equilibrium surplus production model, fishing mortality should be reduced by 60-75% to reach maximum biomass production and $F_{0.1}$ target levels, respectively.

5.11. Stock assessment of hake in GSA 17

5.11.1. Stock identification and biological features

5.11.1.1. Stock Identification

The distribution of hake (*Merluccius merluccius*) in GSA 17 during spring-summer, is shown in the Figure 5.11.1.1.1 below (Sabatella and Piccinetti 2004). The picture on the left provides details on the depth, increasing with darker colour (0-50, 50-100, 100-200, 200-800, > 800 m). The picture on the right displays the hake densities at sea from MEDITS trawl survey in the second half of the 1990s, expressed as number of individuals per square kilometer. In the GSA 17, higher densities are observed in the southern part and at depths between 100 and 200 m.

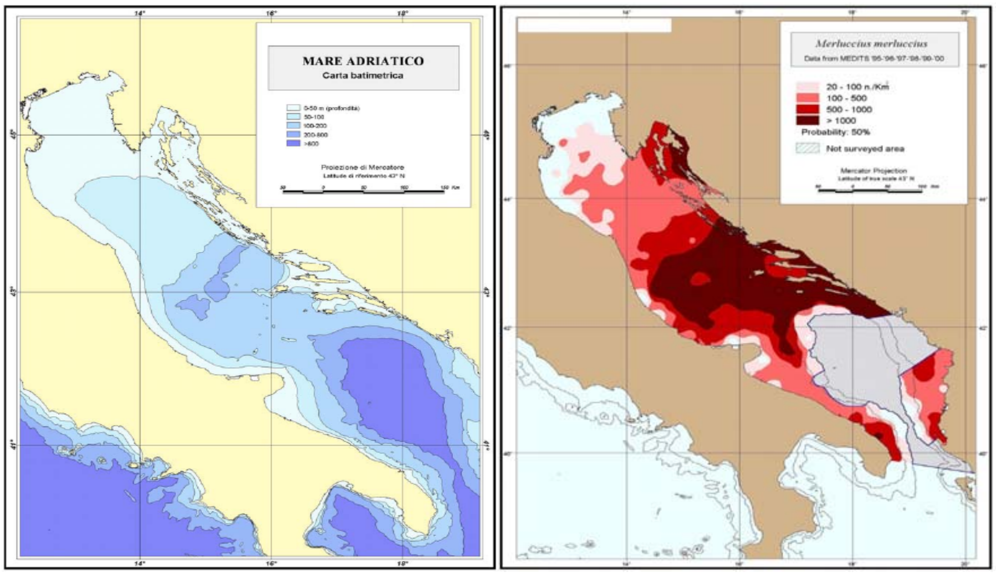


Fig. 5.11.1.1.1 Bathymetric map and hake density in GSA 17 (Sabatella and Piccinetti 2004).

In the subsequent three maps (Fig. 5.11.1.1.2), again from Sabatella and Piccinetti (2004), densities at sea are plotted taking into account different length ranges (increasing in the maps from left to right). In particular, individuals with length lower than 12 cm are concentrated in the southern part of the GSA 17. The individuals with length between 12 and 20 cm display the same pattern but are more diffuse; the same pattern is observed also for the individuals with length higher than 20 cm, but they are more abundant on the eastern side of Adriatic.

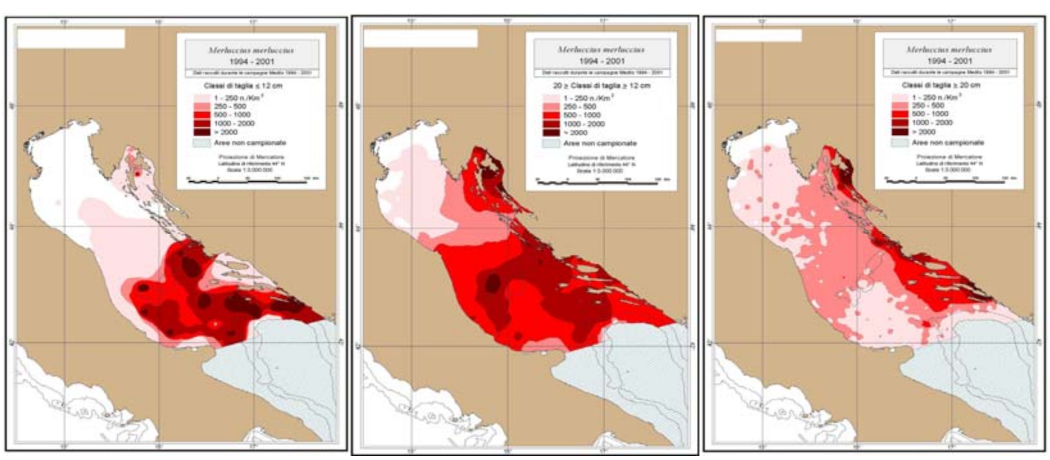


Fig. 5.11.1.1.2 Hake densities by length classes (Sabatella and Piccinetti, 2004)

Spawning of hake occurs throughout the year with two peaks in winter and summer. Earliest spawning occurs in winter in deeper waters, up to 200 m, in the Pomo/Jabuka Pit (where the greatest depths in GSA 17 are observed). In the summer period, spawning occurs in shallower waters. Nursery areas are located close to the Pomo/Jabuka Pit (Vrgoc *et al*., 2004).

5.11.1.2. Growth

No information was documented during SGMED-10-02 from the Italian Data Collection Program.

5.11.1.3. Maturity

No information were documented on maturity at age nor at length during SGMED-10-02 from the Italian Data Collection Program. Maturity at age for the sex combined from data available from GSA 18 was used. A reasonable value of length at first sexual maturity for hake, in the GSA 17, is between 23 and 33 cm for females and between 20 and 28 cm for males, as reported by Zupanovic and Jardas (1986) (mentioned in Vrgoc *et al.*, 2004). The summary of the values of length at the first sexual maturity estimated for the Adriatic Sea was imported from Vrgoc *et al.* (2004), as listed in Table 5.11.1.3.1.

Tab. 5.11.1.3.1 Length at first maturity by sex.

Author	Sex	L_m (cm)
Zei, 1949	M	22-30
Županović, 1968;	M	20-28
	F	26-33
Županović and Jardas, 1986	M	20-28
	F	23-33
Ungaro *et al.*, 1993	M+F	25-30
Cetinić *et al.*, 1999	M+F (Velebit Channel)	24

5.11.2. Fisheries

5.11.2.1. General description of fisheries

The fisheries for hake are one of the most important in the GSA 17. Fishing grounds mostly correspond to the distribution of the stock (SEC (2002) 1374).

5.11.2.2. Management regulations applicable in 2009 and 2010

According to Regulation (EC) 1967/2006 the minimum landing size for hake is 20 cm.

5.11.2.3. Catches

5.11.2.3.1. Landings

On the basis of data collected for Italy through DCR from 2002 to 2008 (Tab. 5.11.2.3.1.1), landings are due mainly to bottom otter trawlers, which account for over 95% of the total. No data are provided in 2009 by the Italian authorities.

Tab. 5.11.2.3.1.1 Hake landings (tonnes) in GSA 17 by fishing technique, 2004-2008.

	Bottom trawls	Miscellaneous	Nets	Pelagic trawls	Surrounding nets	Traps	Total
2004	3,025.7		18.5	0.6		0.1	3,044.9
2005	3,563.0	0.3	45.4	0.2	0.2		3,609.0
2006	4,339.3	3.2	50.9	2.0			4,395.4
2007	3,736.4		27.6	0.1			3,764.1
2008	3,141.7		35.0				3,176.7

Moreover, according to the FAO statistics (ftp://ftp.fao.org/fi/stat/windows/fishplus/gfcm.zip), in the northern and central Adriatic Sea, the annual landings of hake (Fig. 5.11.2.3.1.1) in the 1980s and 1990s were estimated at around 2,000-4,000 t, with some peaks over 5,000 t. A decreasing trend occurred from 1993 to 2000.

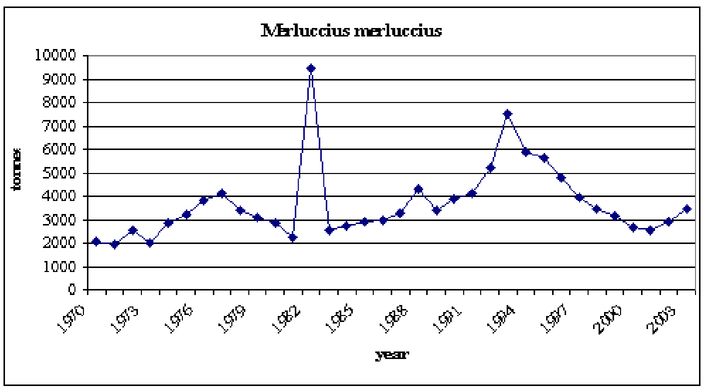


Fig. 5.11.2.3.1.1 FAO landing statistics 1970-2003.

Tab. 5.11.2.3.1.2. Hake landings in GSA 17 by fishing technique, 2004-2009 by country as submitted throught the official DCF data call.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	17	ITA							0	3			
HKE	17	ITA	FPO	DEMSP				0					
HKE	17	ITA	GNS	DEMSP				17	39	47	26	32	
HKE	17	ITA	GTR	DEMSP				2	6	4	2	3	
HKE	17	ITA	OTB	DEMSP				1677	2800	3980	3435	3037	
HKE	17	ITA	OTB	MDDWSP				1261	621	123	90	1	
HKE	17	ITA	OTM	MDPSP						1			
HKE	17	ITA	PS	LPF					0				
HKE	17	ITA	PTM	SPF				1	0	1	0		
HKE	17	ITA	TBB	DEMSP				88	142	237	212	105	
HKE	17	SVN	GND	SPF	20D40						0		
HKE	17	SVN	GNS	DEMSP	16D20				0	2	3	1	1
HKE	17	SVN	GTR	DEMSP	50D100				0	0	0	0	0
HKE	17	SVN	LLS	DEMSP	NA					0			0
HKE	17	SVN	OTB	DEMSP	40D50				4	4	10	2	3
HKE	17	SVN	PS	SPF	14D16						0	0	
HKE	17	SVN	PTM	SPF	20D40						0		

5.11.2.3.2. Discards

No information were documented during SGMED-10-02 from Italian Data Collection Program.

5.11.2.3.3. Fishing effort

Table 5.11.2.3.3.1 reveals an overall decreasing trend in effort of the major bottom otter trawl fleet. No 2009 data were submitted by Italy.

Tab. 5.11.2.3.3.1. Trend in annual effort (days at sea, GT*days, kW*days) by country and gears in GSA 17, 2004-2009. No 2009 data were submitted by Italy.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
17	ITA				VL0006				28839	19464	25018	
17	ITA				VL0612		585226	426770	538249	418073	245003	
17	ITA				VL1218		21467	23352				
17	ITA				VL2440			4097		7903		
17	ITA	DRB	MOL		VL0612		19073					
17	ITA	DRB	MOL		VL1218		581702	484258	407953	612211	492480	
17	ITA	FPO	DEMSP		VL0006				130			
17	ITA	FPO	DEMSP		VL0612		19874	17355	9999	9718	18643	
17	ITA	FYK	DEMSP		VL0006				0	0	0	
17	ITA	FYK	DEMSP		VL0612		6671	333	5572	34133	14013	
17	ITA	GND	SPF		VL0612			214				
17	ITA	GNS	DEMSP		VL0006				27244	4459	16709	
17	ITA	GNS	DEMSP		VL0612		113579	97152	43173	36087	33960	
17	ITA	GNS	DEMSP		VL1218		24644	15559	7559			
17	ITA	GTR	DEMSP		VL0006				0	0		
17	ITA	GTR	DEMSP		VL0612		14415	25334	31121	34778	26522	
17	ITA	GTR	DEMSP		VL1218			7215				
17	ITA	LLD	LPF		VL0612		7472	2384			5843	
17	ITA	LLD	LPF		VL1218		961	9928	6181	3765	416	
17	ITA	LLS	DEMF		VL0612				529	498		
17	ITA	OTB	DEMSP		VL0612		143723	70376	46397	71355	67595	
17	ITA	OTB	DEMSP		VL1218		910397	713888	599979	686576	595477	
17	ITA	OTB	DEMSP		VL1824		822314	379538	639196	779138	713636	
17	ITA	OTB	DEMSP		VL2440		479467	305876	303593	249435	249021	
17	ITA	OTB	MDDWSP		VL1824			455880				
17	ITA	OTB	MDDWSP		VL2440			101556	85117	81784	15108	
17	ITA	OTM	MDPSP		VL0612			666				
17	ITA	OTM	MDPSP		VL2440				963			
17	ITA	PS	SPF		VL0612		15395	11368				
17	ITA	PS	SPF		VL1218		1912	7297	13939	3958	1374	
17	ITA	PS	SPF		VL2440					15557		
17	ITA	PTM	SPF		VL1218		9255	28121	1056		11264	
17	ITA	PTM	SPF		VL1824		446896	309738	331008	393874	93255	
17	ITA	PTM	SPF		VL2440		170745	183571	198308	225578	385407	
17	ITA	TBB	DEMSP		VL1218		32478	16587	30023	74266	54618	
17	ITA	TBB	DEMSP		VL1824		229009	266268	365432	304104	172961	
17	ITA	TBB	DEMSP		VL2440		104553	93303	108658	138558	267487	
17	SVN	FPO	DEMSP	NA	VL0006			738	788	695	1124	382
17	SVN	FPO	DEMSP	NA	VL0012			846	788	695	1145	382
17	SVN	FPO	DEMSP	NA	VL0612			107			20	
17	SVN	FPO	DEMSP	NA	VL1218						6632	11027
17	SVN	FPO	DEMSP	NA	VL1224						6632	11027
17	SVN	FYK	DEMSP	NA	VL0006			165	495	637	18	458
17	SVN	FYK	DEMSP	NA	VL0012			165	554	637	18	458
17	SVN	FYK	DEMSP	NA	VL0612				59			
17	SVN	GND	SPF	20D40	VL0012			1135	227	92	219	141
17	SVN	GND	SPF	20D40	VL0612			1135	227	92	219	141
17	SVN	GND	SPF	20D40	VL1218					355		
17	SVN	GND	SPF	20D40	VL1224					355		
17	SVN	GNS	DEMSP	16D20	VL0006			3624	3368	4616	4970	6367
17	SVN	GNS	DEMSP	16D20	VL0012			20524	20108	20482	47601	53623
17	SVN	GNS	DEMSP	16D20	VL0612			16900	16739	15893	42671	47256
17	SVN	GNS	DEMSP	16D20	VL1218			67	996	8602	4938	861
17	SVN	GNS	DEMSP	16D20	VL1224			67	996	8602	4938	861
17	SVN	GTR	DEMSP	50D100	VL0006			2767	1608	3570	7475	6644
17	SVN	GTR	DEMSP	50D100	VL0012			29427	37010	75895	81751	78489
17	SVN	GTR	DEMSP	50D100	VL0612			26660	35402	72386	74276	71844
17	SVN	GTR	DEMSP	50D100	VL1218			15970		7548	5137	1387
17	SVN	GTR	DEMSP	50D100	VL1224			15970		7548	5137	1387
17	SVN	LHP-LHM	CEP	NA	VL0006							11
17	SVN	LHP-LHM	CEP	NA	VL0012						3	11
17	SVN	LHP-LHM	CEP	NA	VL0612						3	
17	SVN	LHP-LHM	FINF	NA	VL0006					4	3	9
17	SVN	LHP-LHM	FINF	NA	VL0012			10		4	20	12
17	SVN	LHP-LHM	FINF	NA	VL0612			10			17	4
17	SVN	LLS	DEMSP	NA	VL0006			22	13	36	31	22
17	SVN	LLS	DEMSP	NA	VL0012			153	637	36	40	421
17	SVN	LLS	DEMSP	NA	VL0612			131	624		8	399
17	SVN	LLS	DEMSP	NA	VL1218					27		
17	SVN	LLS	DEMSP	NA	VL1224					27		
17	SVN	OTB	DEMSP	40D50	VL0006			17				4
17	SVN	OTB	DEMSP	40D50	VL0012			17615	19313	20311	18128	14912
17	SVN	OTB	DEMSP	40D50	VL0612			18935	27569	34965	37112	40305
17	SVN	OTB	DEMSP	40D50	VL1218			41539	54928	76356	79234	84796
17	SVN	OTB	DEMSP	40D50	VL1224			41539	54928	76356	79234	84796
17	SVN	OTB	DEMSP	40D50	VL2440					600	350	
17	SVN	OTM	MDPSP	20D40	VL1218						47	196
17	SVN	OTM	MDPSP	20D40	VL1224						47	196
17	SVN	OTM	MDPSP	20D40	VL2440							550
17	SVN	PS	SPF	14D16	VL0006							3
17	SVN	PS	SPF	14D16	VL0012			3169	4648	6209	4073	3009
17	SVN	PS	SPF	14D16	VL0612			3169	4648	6209	4073	3005
17	SVN	PS	SPF	14D16	VL1218			14080	15883	11865	12994	20598
17	SVN	PS	SPF	14D16	VL1224			14080	15883	11865	12994	20598
17	SVN	PTM	SPF	20D40	VL2440			100585	91719	110404	69808	102116

5.11.3. Scientific surveys

5.11.3.1. Medits

5.11.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 17 the following number of hauls was reported per depth stratum (Tab. 5.11.3.1.1.1).

Tab. 5.11.3.1.1.1 Number of valid hauls per year and depth stratum in GSA 17, 2002-2009.

STRATUM	2002	2003	2004	2005	2006	2007	2008	2009
GSA17_010-050	57	45	47	61	49	52	51	49
GSA17_050-100	54	36	37	62	38	32	37	37
GSA17_100-200	50	27	22	43	21	24	23	22
GSA17_200-500	9	7	5	7	5	5	5	5
GSA17_500-800	1	1						
Sum	171	116	111	173	113	113	116	113

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.11.3.1.2. Geographical distribution patterns

See section 5.11.1.1.

5.11.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 17 was derived from the international survey MEDITS. Figure 5.11.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 17.

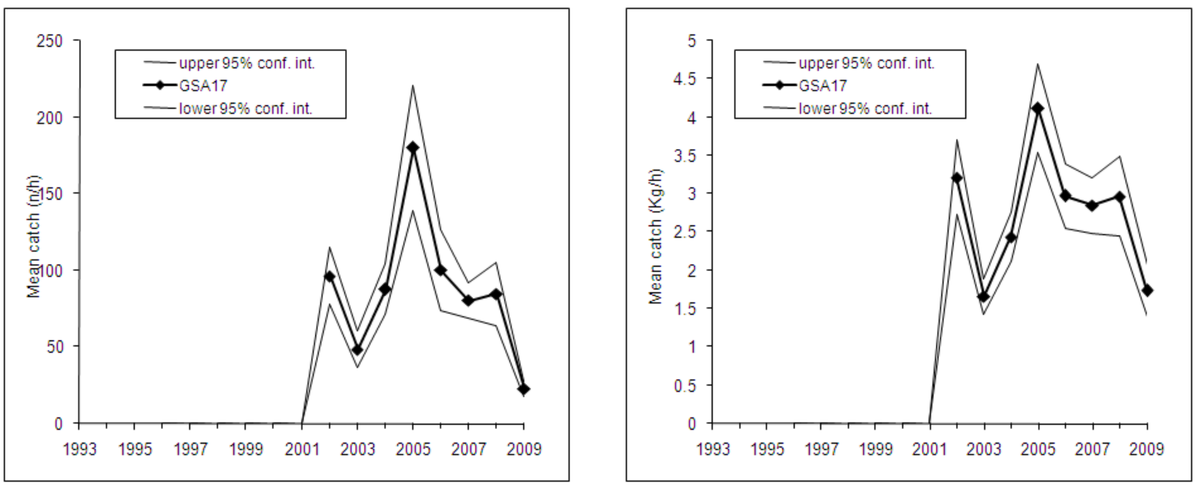


Fig. 5.11.3.1.3.1 Abundance and biomass indices of hake in GSA 17.

5.11.3.1.4. Trends in abundance by length or age

The following Fig. 5.11.3.1.4.1 displays the stratified abundance indices of GSA 17 in 2002-2009.

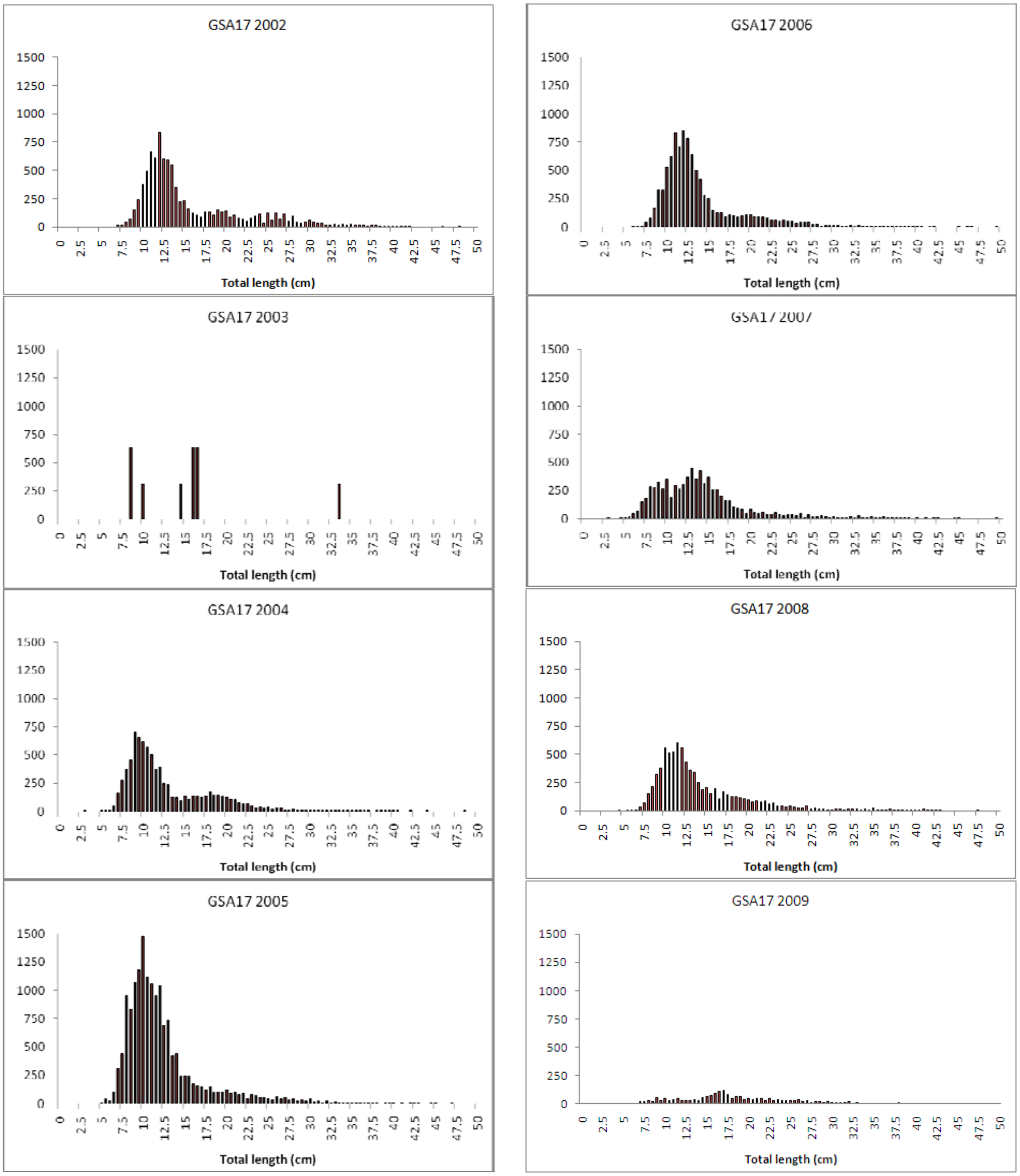


Fig. 5.11.3.1.4.1 Stratified abundance indices by size, 2002-2009.

5.11.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.11.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.11.4. Assessment of historic stock parameters

5.11.4.1. Method 1: Standard VPA (VIT model)

5.11.4.1.1. Jusification

Assessment based on fishery dependent data was carried out in SGMED-10-02. SGMED 09-02 did not undertake any analytical assessment of hake in GSA 17 in 2009. A preliminary assessment using Length Cohort Analysis (LCA) can be found in the report of SGMED-08-04 working group held in 2008.

5.11.4.1.2. Input parameters

The last assessment of this stock was presented in 2008 (SGMED-08-04). It was performed using a pseudocohort analysis with years 2006 and 2007. The result of this assessment was that *M. merluccius* in GSA 17 was fully exploited. This does not agree with the results of the present assessment, but it must be taken into account that the landing data and parameters used were different. In SGMED-08-04 the analysis (LCA) was based on the length distributions of the catches in the years 2006-2007, while the present analysis is performed using age based data set provided in the framework of the DCR. Moreover the von Bertalanffy growth parameters used were different.

Table 5.11.4.1.2.1 Growth parameters used to assess hake in GSA 17 using VIT.

	L_{inf} (cm)	k ($year^{-1}$)	t_0 (year)
SGMED-08-04	78	0.14	0.05
SGMED-10-02	85	0.12	-0.73

In SGMED-08-04 the von Bertalanffy growth parameters used were calculated as weighted means of the values for females and males, by using the sex ratio 0.54. The original values for females (L_{inf} = 84.0, k = 0.13, t_0 = 0.102) and males (Linf = 72.0, k = 0.15, t_0 = -0.005) were estimated for the southern Adriatic Sea by Marano *et al.* (1998b; c, in Vrgoc et al., 2004). In the present assessment the parameters used were from the whole Adriatic Sea (EC XIV/298/96-EN - 1996).

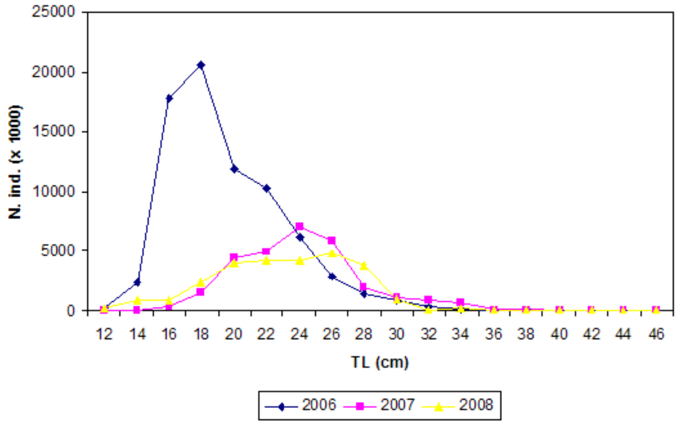
Since there are not data available on length or age- frequency distributions of the discards in GSA 17, discards were not included in the assessment.

Since only three years of age and length landings data are available (2006-2008), a VPA using an approach under steady state was carried out. This analysis is based on the number of individuals by age landed from 2006-2008 in GSA 17. Furthermore, a yield per recruit (Y/R) analysis was also performed. For both analyses, the VIT software (Lleonart and Salat, 1997; 2000) was used.

The age and length frequency distributions showed a similar pattern in the years 2007 and 2008, while in 2006 the landings of age 1 and 2 were higher than the values observed in the other years (Fig. 5.11.4.1.2.1). Due this lack of consistency four different scenarios were evaluated using VIT software:

- Scenario 1: age-landing structure from the average of 2006, 2007 and 2008.
- Scenario 2: age-landing structure from 2006;
- Scenario 3: age-landing structure from 2007;

– Scenario 4: age-landing structure from 2008.



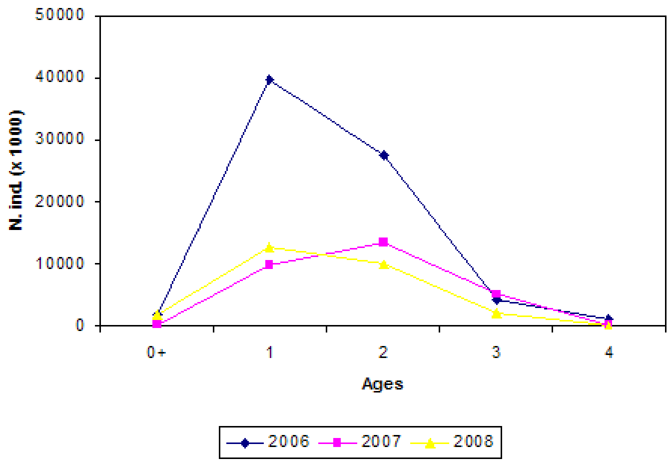


Fig. 5.11.4.1.2.1 Total landings at length and age from 2006 to 2008.

The biological parameters used were the following:

Growth parameters: L_{inf}=85.0, K=0.12, t_0=-0.73.

Length-weight relationships: a=0.006, b=3.057; these data come through the Official Data call.

Natural mortality by age was calculated using the PROBIOM spreadsheet (Abella *et al.*, 1997), obtaining the following vector:

Table 5.11.4.1.2.2 Natural mortality vector as derived from PROBIOM.

Age	0	1	2	3	4	Mean
M	0.68	0.28	0.2	0.16	0.14	0.29

Since the data series is too short (3 years) to calculate the terminal fishing mortality (F_t) from the catch curve, it was estimated by MEDITS data through catch curve analyses of the oldest class ages (F_t= 0.31).

The maturity ogive for the sex combined was obtained through the Official Data call carried out in GSA 18, because no data were available from GSA 17.

Table 5.11.4.1.2.3 Maturity ogive as derived from PROBIOM.

Age	0	1	2	3	4
M	0.00	0.30	0.51	0.79	0.99

5.11.4.1.3. Results

The following Figure 5.11.4.1.3.1 and Table 5.11.4.1.3.1 show the summary results from the standard VPA analysis. These results show that the actual level of exploitation is quite high and concentrated towards ages 2 and 3 in all scenarios, although the absence of discard data could lead to an underestimation of relative F of ages 0 and 1. In all cases, both mean age and mean length are clearly higher in the catch than in the current stock. The figure below shows the vector of fishing mortality by age resulting from the VPA.

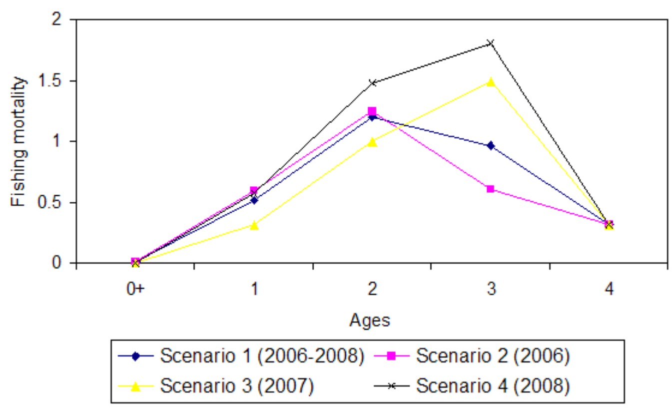


Fig. 5.11.4.1.3.1 Estimated exploitation pattern over age as derived from the VIT model.

Table 5.11.4.1.3.1 Summary results of stock parameters derived from the VIT model.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Catch mean age	1.99	1.92	2.26	1.97
Catch mean length	23.38	22.87	25.38	23.28
Mean F	0.60	0.55	0.62	0.84
Global F	0.30	0.31	0.26	0.32
Mean Z	0.89	0.85	0.91	1.13
Total catch (Tonnes)	4751.25	7622.63	3936.10	2622.62
Catch/D%	71.28	70.13	71.96	73.65
Catch/B%	68.83	64.40	69.04	85.71
Current Stock Mean Age	1.04	1.03	1.11	0.95
Current Stock Mean Length	15.86	15.82	16.41	15.23
Number of recruits, R (millions)	117.65	201.61	83.29	65.40
Mean Biomass, Bmean (Tonnes)	6902.43	11836.47	5700.79	3060.01
Spawning Stock Biomass, SSB (Tonnes)	3252.17	5806.65	2691.63	1191.19
Biomass Balance, D (Tonnes)	6665.59	10868.87	5469.79	3560.72
Natural death/D	28.72	29.87	28.04	26.35

5.11.5. Long term prediction

5.11.5.1. Justification

A Y/R analysis was conducted.

5.11.5.2. Input parameters

Same data and parameters used in the VIT analyses described in the previous sections.

5.11.5.3. Results

The following Table 5.11.5.3.1 lists the results from the Y/R analysis, whereas the Fig. 5.11.3.3.1 below shows the evolution of Y/R when the actual level of exploitation (factor=1) is doubled (factor=2) for the four scenarios considered. The figure and the table indicate a state of overexploitation in all scenarios, more accentuated in the scenario 4 (year 2008).

Tab. 5.11.5.3.1 Results of the Y/R analysis.

	Scenario 1				Scenario 2			
Phi	Factor	Y/R	B/R	SSB	Factor	Y/R	B/R	SSB
Absence of fishing	0	0	281.042	211.936	0	0	281.042	211.936
$F_{0.1}$	0.52	40.517	109.101	66.703	0.55	37.406	106.517	65.896
Y/R_{max}	0.73	41.859	81.797	45.074	0.77	38.716	78.796	44.019
Current	1.01	40.383	58.667	27.642	1.01	37.809	58.711	28.802
Max factor	2	31.479	29.372	8.506	2	29.966	27.715	7.981
	Scenario 3				Scenario 4			
Phi	Factor	Y/R	B/R	SSB	Factor	Y/R	B/R	SSB
Absence of fishing	0	0	281.042	211.936	0	0	281.042	211.936
$F_{0.1}$	0.53	46.88	115.064	68.949	0.39	43.5	109.852	65.926
Y/R_{max}	0.75	48.539	88.65	47.726	0.55	44.915	83.564	45.019
Current	1.01	47.26	68.448	32.318	1.01	40.102	46.79	18.214
Max factor	2	37.971	38.538	12.491	2	30.273	26.442	6.677

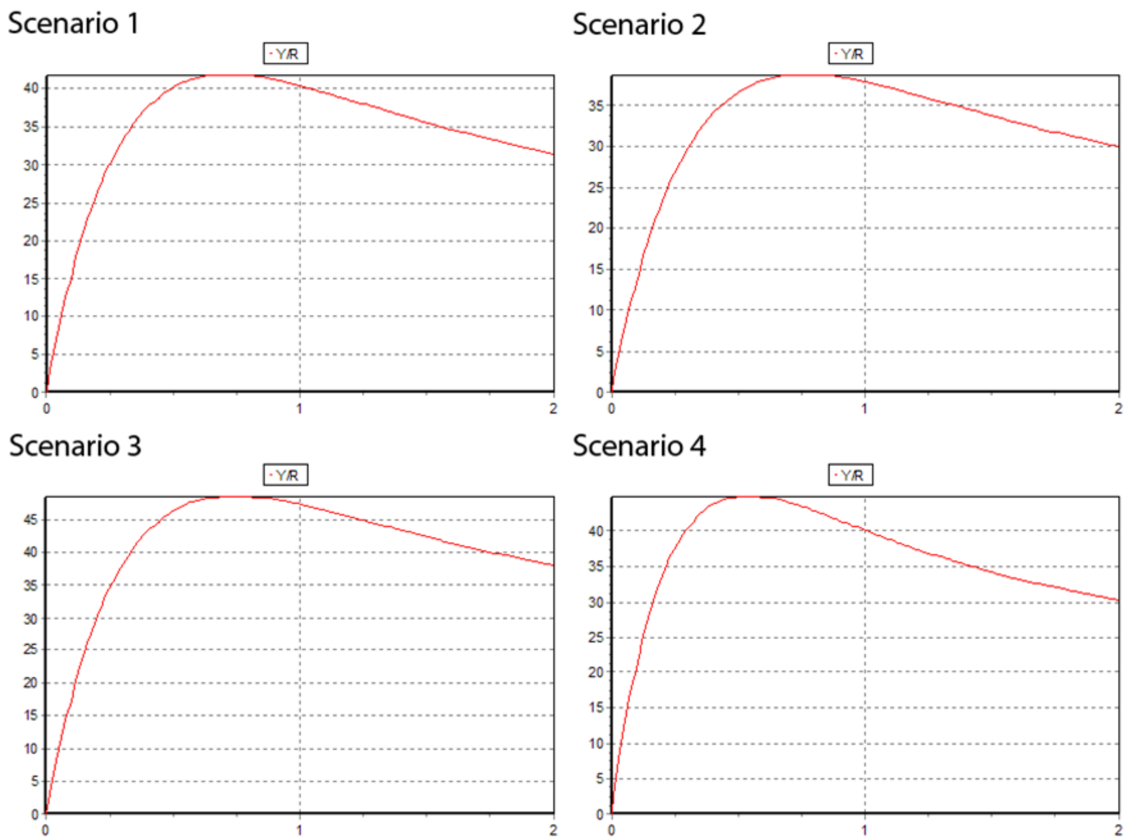


Fig. 5.11.5.3.1 Results of the Y/R analysis.

5.11.6. Data quality and data consistency

Fisheries independent information from MEDITS survey are available only for the period 2002-2009, although the experimental trawl survey has been carried out since 1994. Moreover only in the years 2002, 2003 and 2005 the data available are from the entire GSA, while in the remaining years are only from the western side of the basin. Thus the trends and the demography showed in the present document are seriously biased by the spatial incongruity of the information provided.

Total landings of hake are provided in GSA 17 from the Italian National Data Collection for the period 2004-2008. Nevertheless, age and size structures of the landings are provided only for the period 2006-2008, thus the data series is too short for analytical assessment methods not based on steady state. The size structures of the landings have shown different distributions, 2006 showed a positively skewed distribution of the landings with the mode at 18 cm and a long tail to the right, while 2007 and 2008 size structures showed a bell shaped distribution, with the main peaks respectively at 22 and 24 cm. In the former case the percentage of specimens smaller than MLS was equal to 54%, instead in the latter ones smaller portions of undersized specimens were landed, respectively 7% and 16%. It is quite difficult to understand if the reasons of such discrepancies are related to changes of the fishing grounds exploited by the fleet or in changes in the sampling design or others.

No growth parameters were provided, as well as maturity at age or maturity at length data. No data on discard quantity and size or age distribution were provided for hake in GSA 17, although scientific papers reported the presence of discard for the species in the GSA 17 (e.g. Sánchez *et al*. 2007; Lucchetti, 2008).
Data on effort related to the otter trawler seem to be underestimated, considering the importance of this activity operating in the area and were not used.

In summary, the inconsistency in the data of landing at age and landing at size observed in the period analysed, the uncertainties about the effort data, the shortage of the time series of fishery dependent data, the complete lack of fishery data from 2009, the fact that the survey data (MEDITS) from 1994 to 2001 were not submitted by the MS, as well as the entire GRUND time series that started in the middle of 1980s, and also the lack of information regarding both discard data and biological parameters, require that a complete revision of the data collection activity and data management should be carried out for the GSA 17 as a matter of urgency.

5.11.7. Scientific advice

5.11.7.1. Short term considerations

5.11.7.1.1. State of the spawning stock size

The spawining stock biomass estimated by VPA in the four scenarios ranged from 1,200 to 5,800 tonnes. Without any biomass reference proposed or agreed, SGMED-10-02 is unable to fully evalute the state of the stock size.

5.11.7.1.2. State of recruitment

The average number of recruits estimated by VPA in the four scenarios ranged from 65 to 200 millions of specimens. SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.11.7.1.3. State of exploitation

SGMED-10-02 proposes the estimated $F_{0.1}$=0.33 as proxy for Fmsy and as a sustainable management reference limit consistent with high long term yields.

In the four scenarios, the values of the current F ranges from 0.55 to 0.84 and the values of $F_{0.1}$ from 0.3 to 0.33, thus the stock of hake in GSA17 can be considered overexploited. Moreover, according to Rochet and Trenkel (2003), it would be safe to avoid F/Z higher than 0.50: the estimated values of F/Z based on the current F in all scenarios were from 0.62 to 0.74. Finally, a meaningful percentage of caught hake has a length below the values of sexual maturity: this is a further reason for caution in managing this stock.

5.12. Stock assessment of hake in GSA 18

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.12.1. Stock identification and biological features

5.12.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.12.1.2. Growth

No information was documented during SGMED-10-02.

5.12.1.3. Maturity

No information was documented during SGMED-10-02.

5.12.2. Fisheries

5.12.2.1. General description of fisheries

STECF (Consolidated Advice on Stocks of Interest to the European Community, 2009) noted that *Merluccius merluccius* is one of the most important species in the Geographical Sub Area 18 representing more than 20% of landings from trawlers. Trawling represents the most important fishery activity in the southern Adriatic Sea and a yearly catch of around 30,000 tonnes could be estimated for the last decades. Demersal species catches are landed on the western side (Italian coast) and the eastern side (Albanian coast), with an approximate percentage of 97% and 3%, respectively. Trawling is the most important fishery activity on the whole area (about 900 boats, 60% of total number of fishing vessels; 85% of gross tonnage). The Mediterranean hake is also caught by off-shore bottom long-lines, but these gears are utilised by a low number of boats (less than 5% of the whole South-western Adriatic fleet).

5.12.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.12.2.3. Catches

5.12.2.3.1. Landings

SGMED-10-02 received the following information about hake landings in GSA 18 through the official DCR data call (Tab. 5.12.2.3.1.1). Italy has not provided landings in 2009. Landings by demersal trawlers dominate by far.

Tab. 5.12.2.3.1.1 Hake landings in GSA 18 by fishing technique, 2004-2008.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	18	ITA							1	1	0		
HKE	18	ITA	GNS	DEMSP				19	38	30	19	15	
HKE	18	ITA	GNS	SLPF								0	
HKE	18	ITA	GTR	DEMSP				21	18	26	18	42	
HKE	18	ITA	LLD	LPF						0		0	
HKE	18	ITA	LLS	DEMF				233	452	836	620	551	
HKE	18	ITA	OTB	DEMSP				195	55	1113	923	3330	
HKE	18	ITA	OTB	DWSP								3	
HKE	18	ITA	OTB	MDDWSP				2737	3221	3500	2575	311	
HKE	18	ITA	PTM	SPF				0					
Sum								3205	3785	5506	4155	4252	

5.12.2.3.2. Discards

No information was documented during SGMED-10-02.

5.12.2.3.3. Fishing effort

Tab. 5.12.2.3.3.1 lists the fishing effort reported to SGMED-10-02 through the DCR data call. Italy has not provided effort data for 2009.

Tab. 5.12.2.3.3.1 Fishing effort in different units by fishing technique deployed in GSA 18, 2004-2008.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
18	ITA				VL0006						653	
18	ITA				VL1218				18973			
18	ITA	DRB	MOL		VL1218		31755	15206	60312	29038	24106	
18	ITA	GNS	DEMSP		VL0006				0	0	0	
18	ITA	GNS	DEMSP		VL0612		79455	107014	73603	59052	76376	
18	ITA	GNS	DEMSP		VL1218				11360			
18	ITA	GTR	DEMSP		VL0006				0	767	3639	
18	ITA	GTR	DEMSP		VL0612		9276	16931	947		48849	
18	ITA	LHP-LHM	CEP		VL0006						1115	
18	ITA	LHP-LHM	CEP		VL0612				0			
18	ITA	LLD	LPF		VL0006						1453	
18	ITA	LLD	LPF		VL0612				0		1686	
18	ITA	LLD	LPF		VL1218			4999		3454		
18	ITA	LLS	DEMF		VL0006				1031	0	731	
18	ITA	LLS	DEMF		VL0612		2168	8862	8103	21686	24959	
18	ITA	LLS	DEMF		VL1218			4999	7077	43626	84915	
18	ITA	OTB	DEMSP		VL0612		31970	31096	30666	13651	27993	
18	ITA	OTB	DEMSP		VL1218				566531		485808	
18	ITA	OTB	DEMSP		VL1824						182427	
18	ITA	OTB	DEMSP		VL2440		36432				122656	
18	ITA	OTB	MDDWSP		VL0612		1409					
18	ITA	OTB	MDDWSP		VL1218		426469	539707		486560	49978	
18	ITA	OTB	MDDWSP		VL1824		390285	349132	553919	455935	44323	
18	ITA	OTB	MDDWSP		VL2440		339413	244695	123388	144908	4025	
18	ITA	PS	SPF		VL2440					27636	10183	
18	ITA	PTM	SPF		VL2440		74992	112819	141218	191256	128292	

5.12.3. Scientific surveys

5.12.3.1. Medits

5.12.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 18 the following number of hauls was reported per depth stratum (s. Tab. 5.12.3.1.1.1).

Tab. 5.12.3.1.1.1. Number of hauls per year and depth stratum in GSA 18, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA18_010-050	14	15	15	14	14	14	14	15	13	13	12	9	10	11	10	10
GSA18_050-100	14	14	14	15	15	15	15	14	21	21	23	16	15	15	14	13
GSA18_100-200	24	23	23	23	23	23	23	23	34	31	32	25	25	23	22	25
GSA18_200-500	10	10	10	10	10	10	10	10	15	15	16	10	10	9	8	11
GSA18_500-800	10	10	10	10	10	10	10	10	14	14	14	7	7	7	5	6

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.12.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.12.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 18 was derived from the international survey Medits. Figure 5.12.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 18.

The estimated abundance indices do not reveal any significant trends since 1995 until 2003, increased to the highest values in 2005 and dropped sharply to an average level of the time series thereafter. The high biomass estimate in 2008 remain to be validated.

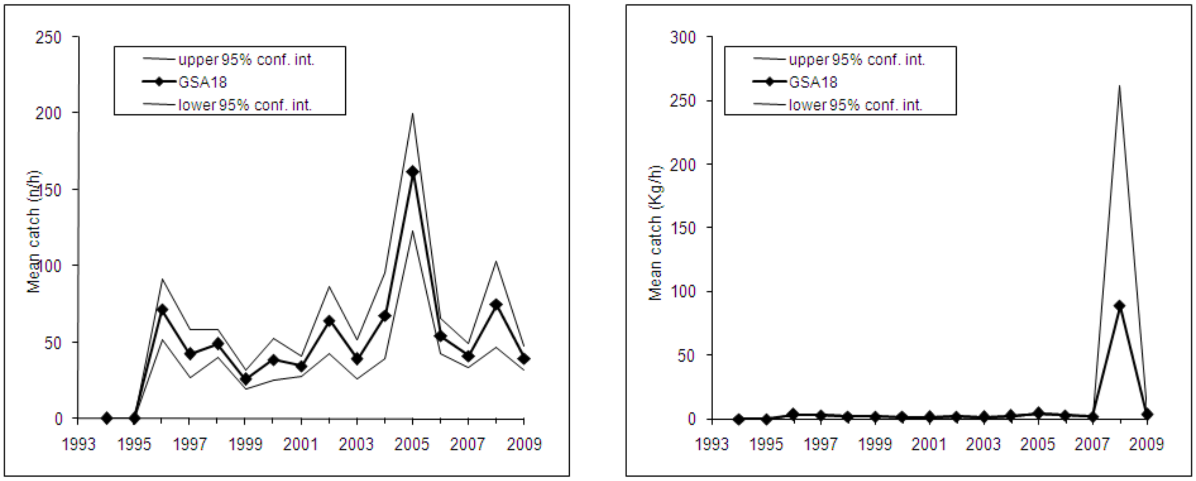


Fig. 5.12.3.1.3.1 Abundance and biomass indices of hake in GSA 18.

5.12.3.1.4. Trends in abundance by length or age

The following Fig. 5.12.3.1.4.1 and 2 display the stratified abundance indices of GSA 18 in 1996-2003 and 2004-2009. These size compositions are considered preliminary.

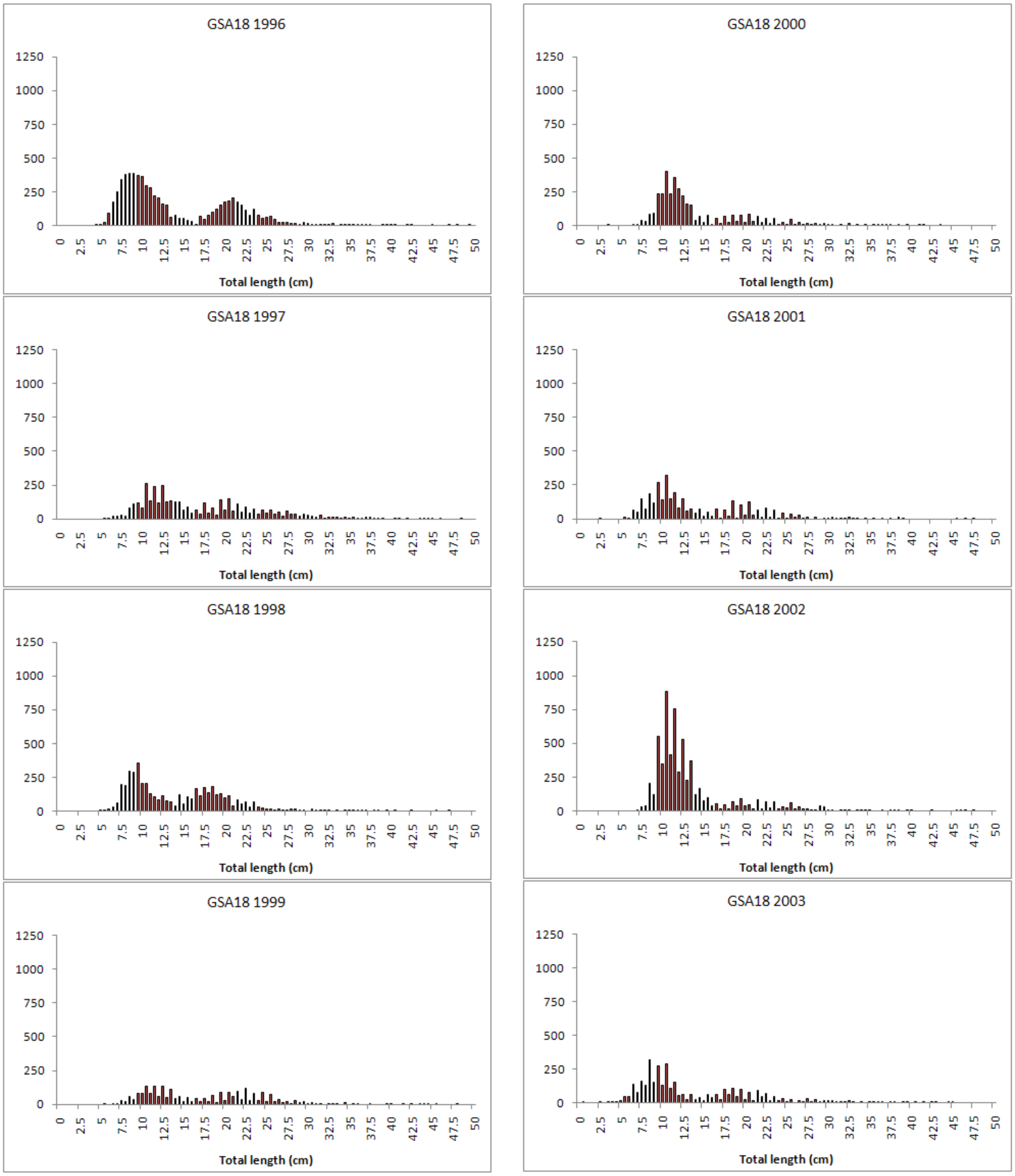


Fig. 5.12.3.1.4.1 Stratified abundance indices by size, 1996-2003.

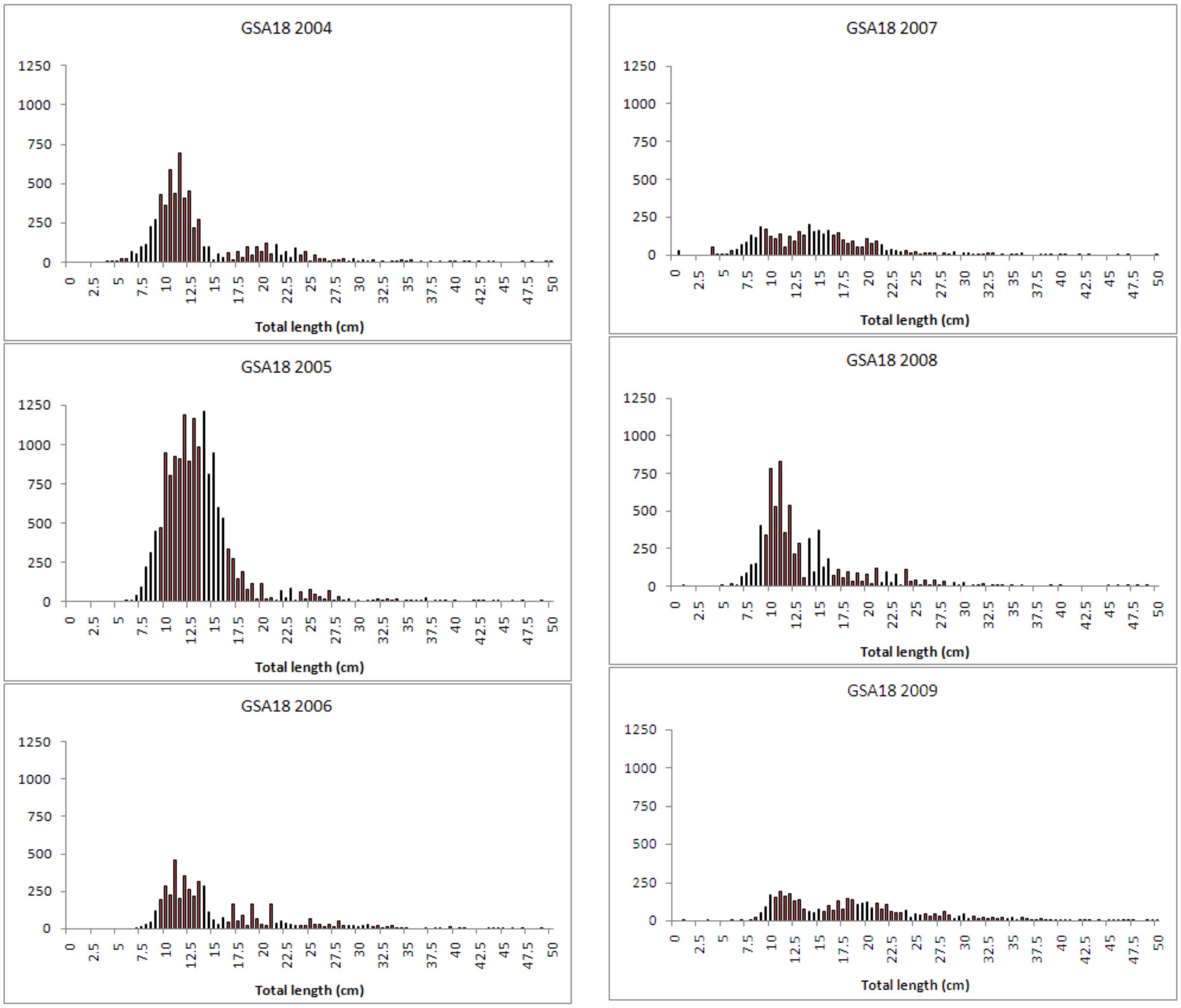


Fig. 5.12.3.1.4.2 Stratified abundance indices by size, 2004-2009.

5.12.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.12.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.12.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.12.5. Long term prediction

5.12.5.1. Justification

No forecast analyses were conducted.

5.12.5.2. Input parameters

No forecast analyses were conducted.

5.12.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for hake in GSA 18.

5.12.6. Scientific advice

5.12.6.1. Short term considerations

5.12.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.12.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.12.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation in relation to proposed precautionary and target levels given the preliminary state of the data and analyses.

5.13. Stock assessment of hake in GSA 19

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

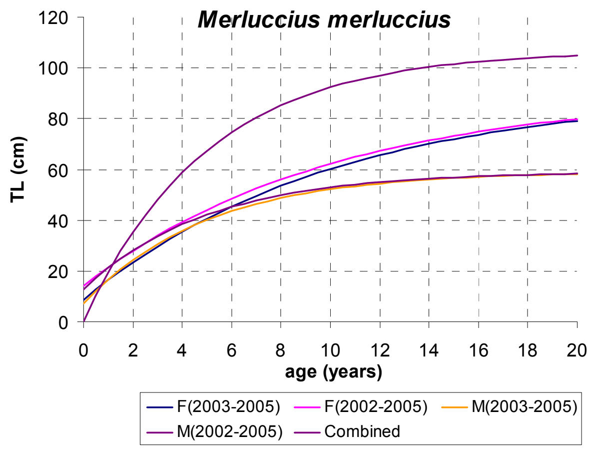
5.13.1. Stock identification and biological features

5.13.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.13.1.2. Growth

Three sets of data on growth parameters were submitted, for females (F) and males (M) separately, estimated by otolith reading. Since the assessment was done for males and females combined, the growth parameters used were those proposed by García-Rodríguez and Esteban (2002), estimated by otolith reading and length frequency analysis, which correspond to the "fast growth" hypothesis, in line with the recommendations of SGMED in previous meetings. These growth parameters were used in the assessment of hake in GSA 19.
Three sets of data on the paramenters of the length-weight relationship were submitted, for females and males separately, and one set for both sexes combined, which were those used in the assessment.



		a	b
2003-2005	F	0,0036	3,100
2008	F	0,0047	3,134
2002-2005	F	0,0036	3,100
2003-2005	M	0,004	3,100
2008	M	0,0045	3,150
2002-2005	M	0,004	3,100
2008	C	0,0048	3,129

Fig. 5.13.1.2.1 V. Bertalanffy growth functions and parameters by sex.

5.13.1.3. Maturity

Three sets of data on the percentage of mature individuals by size and sex, two for females and one for males, were submitted to SGMED-10-02. According to these sets, size-at-first-maturity (50% of individual mature, L_{50}) would be around 18 cm TL for males and 34 cm TL for females. The observed L_{50} for females is similar to that determined in other Mediterranean areas.

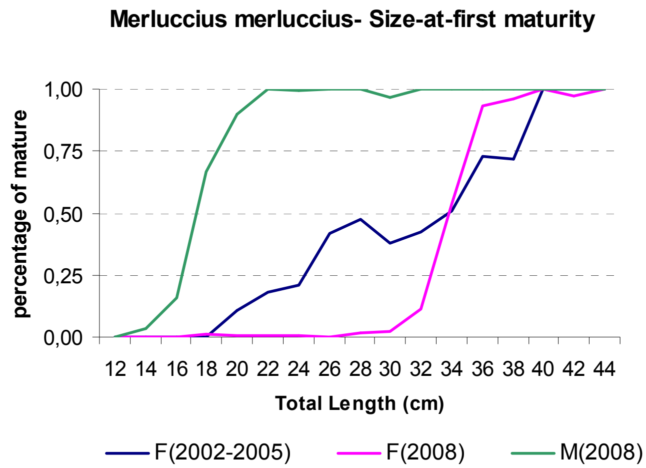


Fig. 5.13.1.3.1 Maturity ogives by sex.

5.13.2. Fisheries

5.13.2.1. General description of fisheries

STECF (Consolidated Advice on Stocks of Interest to the European Community, 2009) noted that *Merluccius merluccius* is one of the most important species in the GSA 19, considering both the amount of catch and the commercial value. It is fished with different strategies and gears (bottom trawling and long-line). In the year 2004 the landings in the Ionian area were detected around 850 tonnes (IREPA data). The main fisheries operating in GSA 19 are Gallipoli, Taranto, Schiavonea and Crotone. The fishing pressure varies between fisheries and fishing grounds. No new documentation on the hake fishery in GSA 19 was submitted to SGMED-10-02.

5.13.2.2. Management regulations applicable in 2009 and 2010

No information was documented.

5.13.2.3. Catches

5.13.2.3.1. Landings

Since 2002 until 2006, landings as provided to SGMED-10-02 through the DCR data call, varied between 1,300 and 1,600 t. In 2007 and 2008, landings dropped significantly regarding the period 2002-2006 (Tab. 5.13.2.3.1.1). Demersal otter trawls (OTB) appear the major fishing gear at present. Current landings are similar to those in 2002 and 2003, although the current OTB fishing effort is much higher than in 2002 and 2003. Landings by nets were much higher during 2002-2003, when the fishing effort of this fishing technique was much higher than at present (see Tab. 5.13.2.3.3.1).

Tab. 5.13.2.3.1.1 Hake landings in GSA 19 by fishing technique, 2002-2008.

landings	2002	2003	2004	2005	2006	2007	2008
OTB	688	668	852	1077	1330	572	635
NETS	653	845	308	123	218	257	206
LONGLINE			139	72	81	54	39
PURSE SEINE	15	1					
ALL	1356	1514	1299	1272	1629	883	879

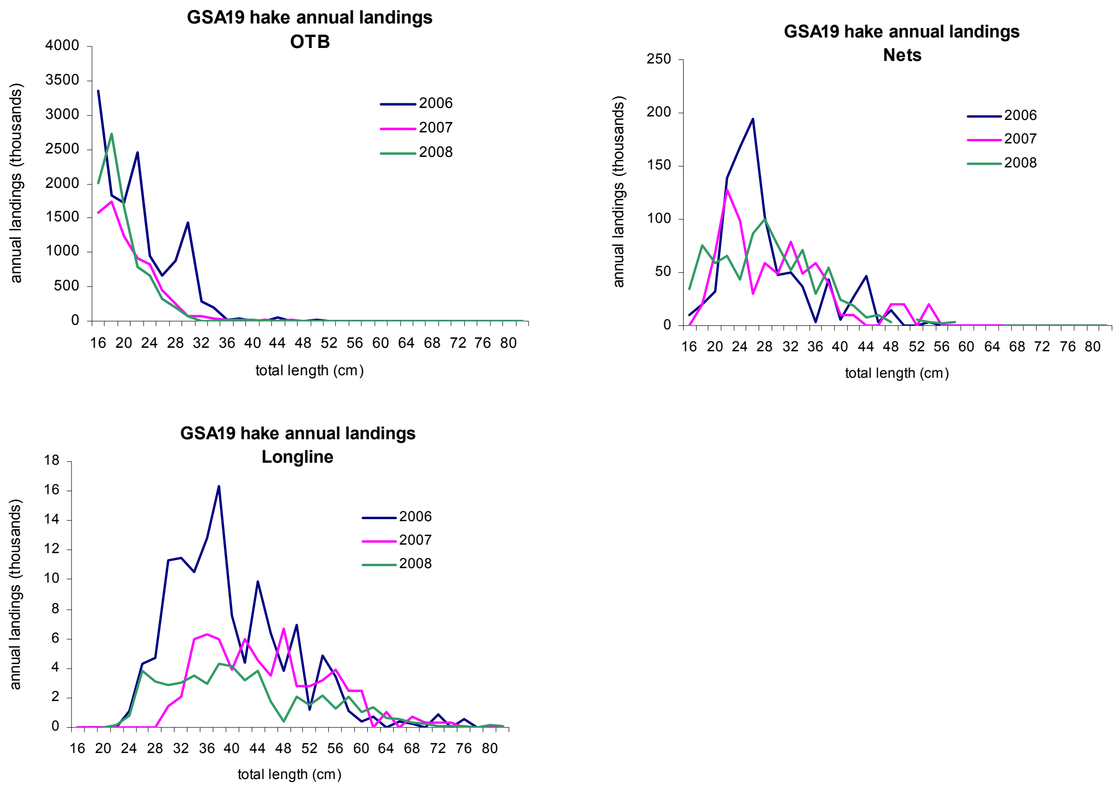


Fig. 5.13.2.3.1.1 Size frequency distributions, by fishing technique, 2006-2008.

By far, highest landings in number correspond to bottom otter trawl, most of them made up of immature individuals. The smallest landed recorded size class is 16 cm TL. Gillnets fish immature and mature individuals, while long lining landings correspond to mature individuals (Data submitted to SGMED-10-02).

Tab. 5.13.2.3.1.2 Hake landings in GSA 19 by fishing technique, 2004-2008 as submitted in accordance with the official DCF data call in 2010. Italy has not reported landings in 2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
HKE	19	ITA						0	0				
HKE	19	ITA	GNS	DEMSP				35	20	8		37	
HKE	19	ITA	GNS	SLPF								1	
HKE	19	ITA	GTR	DEMSP				7	9	92	25	16	
HKE	19	ITA	LLD	LPF						64	12	0	
HKE	19	ITA	LLS	DEMF				204	147	136	275	196	
HKE	19	ITA	OTB	DEMSP				200	29	52	14	292	
HKE	19	ITA	OTB	DWSP						40	20	19	
HKE	19	ITA	OTB	MDDWSP				854	1050	1238	537	372	
HKE	19	ITA	PS	LPF					0				
HKE	19	ITA	PS	SPF					17				
HKE	19	ITA	PTM	SPF						0			
HKE	19	ITA	SB-SV	DEMSP				0	0				
Sum								1300	1272	1630	883	933	

5.13.2.3.2. Discards

Discards reported to SGMED-09-02 amount to 10 t in 2006, estimated for demersal otter trawls only. Hake discard was less than 10% in weight so, according to the national protocol, the length distributions were not presented in the data.

5.13.2.3.3. Fishing effort

The data reported in 2010 in accordance with the DCF data call are given in Table 5.13.2.3.3.1. No data were reported by Italy for 2009.

Tab. 5.13.2.3.3.1 Fishing effort by fishing technique deployed in GSA 19, 2004-2008. No data are available for 2009.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
19	ITA				VL0006				0	1589	1289	
19	ITA				VL0612		43727	21997	57851	74979	39123	
19	ITA				VL1218		9424	43715	40060	28934	51895	
19	ITA	FPO	DEMSP		VL0612		25169	2690	3229	4066	4330	
19	ITA	FPO	DEMSP		VL1218		8894				52399	
19	ITA	GND	SPF		VL0006				0	0		
19	ITA	GND	SPF		VL0612		60866		4327	14947	13293	
19	ITA	GND	SPF		VL1218				6437	33090		
19	ITA	GNS	DEMSP		VL0006				0	2317	2514	
19	ITA	GNS	DEMSP		VL0612		42380	52151	52916	116463	56469	
19	ITA	GNS	DEMSP		VL1218		19276	5898	8441		3077	
19	ITA	GTR	DEMSP		VL0006				1576	0	3994	
19	ITA	GTR	DEMSP		VL0612		93233	21618	28909	49607	73983	
19	ITA	GTR	DEMSP		VL1218		37514		9694	22498	33993	
19	ITA	LHP-LHM	CEP		VL0612		0	0			901	
19	ITA	LLD	LPF		VL0006				0	0		
19	ITA	LLD	LPF		VL0612		21059	2262			1613	
19	ITA	LLD	LPF		VL1218		24556	11063		49548	86997	
19	ITA	LLD	LPF		VL1824		130836	29278	87254	162415	221621	
19	ITA	LLS	DEMF		VL0006				0	335	281	
19	ITA	LLS	DEMF		VL0612		32056	17304	941	31232	31930	
19	ITA	LLS	DEMF		VL1218		6788	25928	12992	30438	38940	
19	ITA	LLS	DEMF		VL1824		9101					
19	ITA	LTL	LPF		VL0612				2903			
19	ITA	OTB	DEMSP		VL1218		20694	128112			171458	
19	ITA	OTB	DEMSP		VL1824		45169				18603	
19	ITA	OTB	DWSP		VL1218					57896		
19	ITA	OTB	MDDWSP		VL1218		246735	207953	386565	396114	254049	
19	ITA	OTB	MDDWSP		VL1824		24687	97647	28684	44800	37335	
19	ITA	PS	LPF		VL1218				5610			
19	ITA	PS	SPF		VL0612			28041			6985	
19	ITA	PS	SPF		VL1218		94936		9833	49469	43538	
19	ITA	SB-SV	DEMSP		VL0612		17636					
19	ITA	SB-SV	DEMSP		VL1218		7479		25107		2220	
19	ITA	SB-SV	DEMSP		VL1824		33305					

5.13.3. Scientific surveys

5.13.3.1. MEDITS

5.13.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 19 the following number of hauls was reported per depth stratum (s. Tab. 5.13.3.1.1.1).

Tab. 5.13.3.1.1.1. Number of hauls per year and depth stratum in GSA 19, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA19_010-050	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9
GSA19_050-100	7	8	8	8	8	8	8	8	8	8	8	8	8	9	8	8
GSA19_100-200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	10
GSA19_200-500	16	15	15	15	15	15	15	15	21	21	14	15	14	14	14	14
GSA19_500-800	31	32	32	32	32	32	32	32	29	29	29	28	29	29	29	30

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.13.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.13.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 19 was derived from the international survey MEDITS. Figure 5.13.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 19.

The time series of estimated abundance and biomass indices indicate that the stock is more abundant since 2004 with high interannual fluctuations.

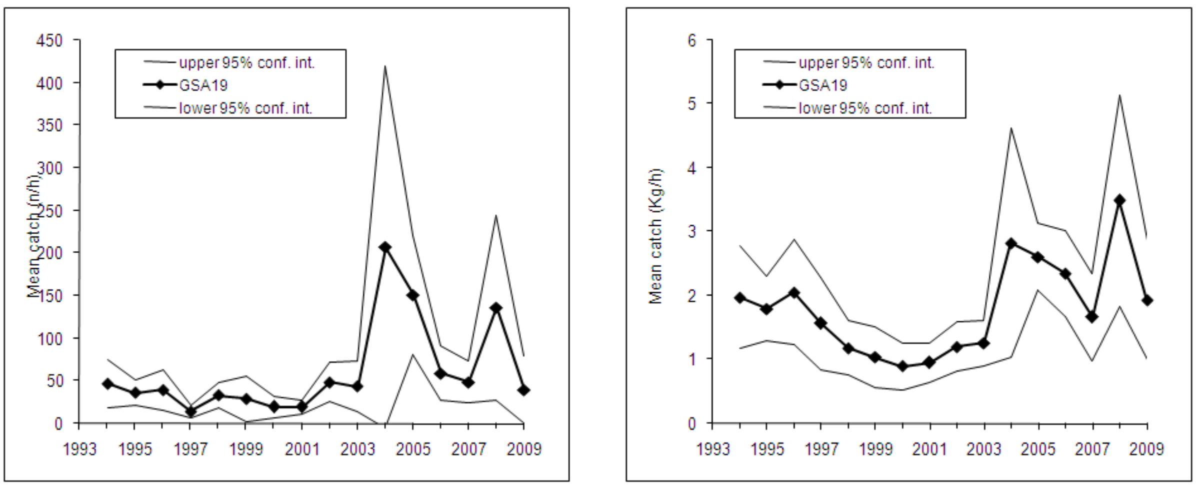


Fig. 5.13.3.1.3.1 Abundance and biomass indices of hake in GSA 19.

5.13.3.1.4. Trends in abundance by length or age

The following Fig. 5.13.3.1.4.1 and 2 display the stratified abundance indices of GSA 19 in 1994-2001 and 2002-2009, respectively. These size compositions are considered preliminary.

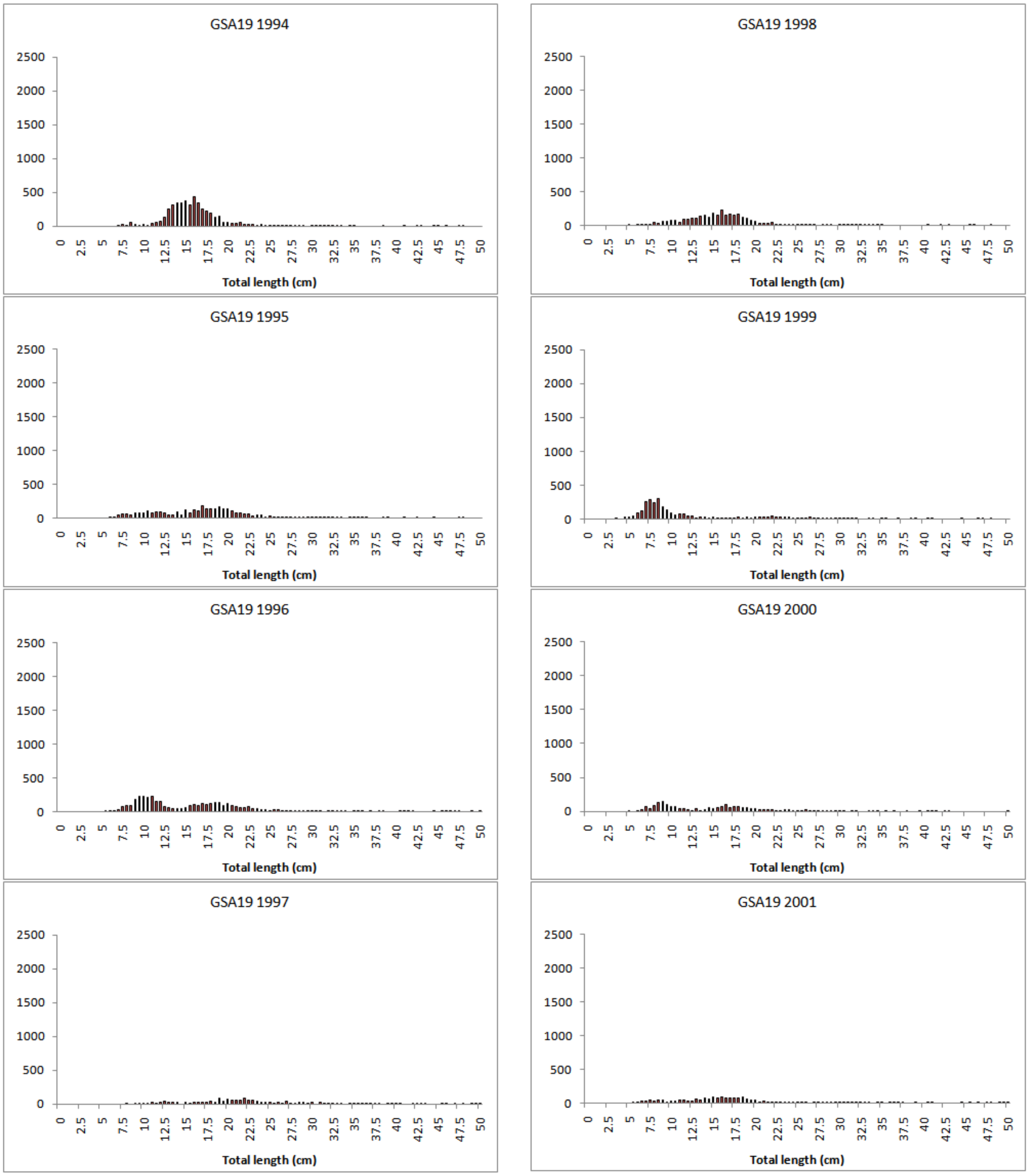


Fig. 5.13.3.1.4.1 Stratified abundance indices by size, 1994-2001.

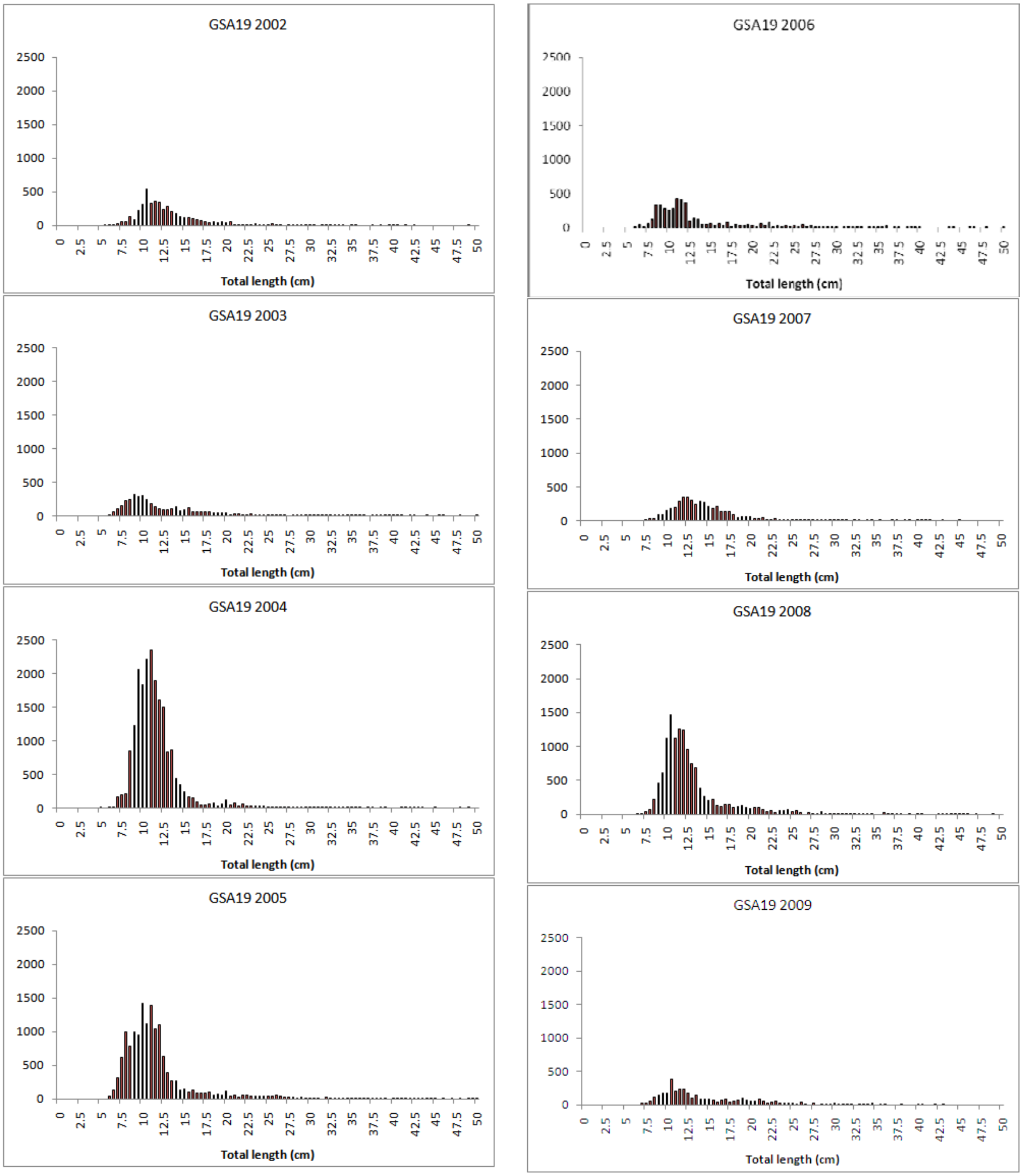


Fig. 5.13.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.13.3.1.5. Trends in growth

No analyses were conducted.

5.13.3.1.6. Trends in maturity

No analyses were conducted.

5.13.4. Assessment of historic stock parameters

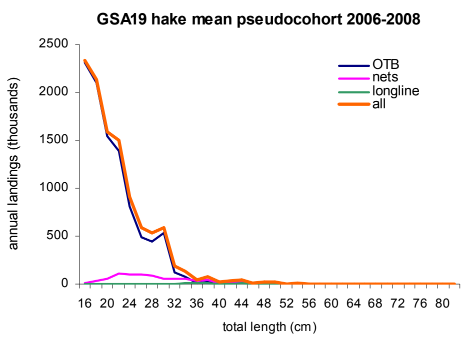
5.13.4.1. Method 1: VIT

5.13.4.1.1. Justification

The following analysis has been done by SGMED 09-02 in 2009. VPA analysis was performed using VIT program (Lleonart and Salat, 1992) using as input data the mean pseudo-cohort for the period 2006-2008 to provide a general overview of the current state of exploitation of hake in GSA 19.

5.13.4.1.2. Input Data

Size distribution data were available only for 2006-2008. VIT was performed using as input size distribution by fishing technique the corresponding "mean" pseudo- cohort for the period 2006-2008, estimated from the annual length distribution of landings. In any case, according to the landings and effort data in Tab. 5.13.2.3.1.1 and Tab. 5.13.2.3.3.1, the hake fishery does not appear to be in equilibrium.



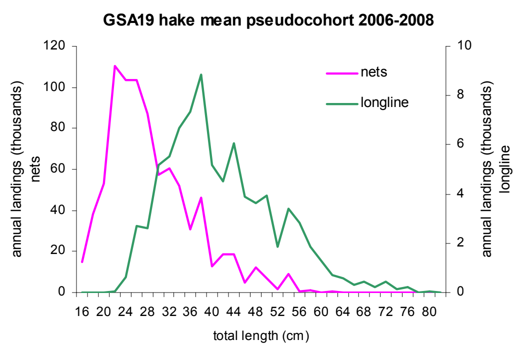


Fig. 5.13.4.1.2.1 Size compositions of landings by gears.

The size distribution of the total landings is very similar to that of bottom trawl and consists mostly of <30 cm TL individuals. The size distribution of gillnets and longline landings are also presented separately, to show the different size-ranges exploited by each gear. Since the smallest landed size is 16cm TL, and also considering the size distribution obtained by OTB, this species should be discarded although data on discards were not available.

About the observed landed sizes by fishing technique, gillnets (assumed to be both trammel net and gillnet) and longline landings overlap over a wide size range. The mode of the nets landings (around 24-28 cm TL) and that of long line (around 40 cm TL) are smaller than those reported for gillnets and longline in other Mediterranean areas.Some inconsistencies were observed between the annual size distributions by gear and the landings expressed in weight.

Growth parameters were taken from García-Rodríguez and Esteban (2002); length-weight relationship parameters and maturity ogive for females were submitted to SGMED 09-02; and M Vector by age was estimated using PROBIOM (Caddy and Abella, 1999). M_{mean} as estimated from PROBIOM is 0.43. Weight at length and maturity at length were transformed into ages during the analysis.

Tab. 5.13.4.1.2.1 VIT Input parameters.

Lin	k	to	a	b
106,8	0,2	0,0028	0,0048	3,1285

number of classes, by length	34
number of fishing gears	3
lower limit of the first class	16
class interval	2
plus group	no

class number	2006-2008 OTB	2006-2008 nets	2006-2008 long line	GSA19 Fem Maturity
1	2315,47	14,71	0,00	0,00
2	2099,61	38,41	0,00	0,01
3	1541,17	53,18	0,01	0,01
4	1384,94	110,70	0,04	0,01
5	811,91	103,36	0,63	0,01
6	484,92	103,43	2,70	0,00
7	445,58	87,14	2,62	0,01
8	529,10	57,48	5,19	0,02
9	122,33	60,37	5,55	0,11
10	79,87	52,09	6,69	0,54
11	11,54	31,04	7,35	0,93
12	22,79	45,99	8,85	0,96
13	5,24	12,97	5,19	1,00
14	7,61	18,58	4,50	0,97
15	16,75	18,38	6,07	1,00
16	3,69	4,71	3,87	1,00
17	1,70	12,36	3,65	1,00
18	7,24	6,65	3,95	1,00
19	0,99	1,75	1,86	1,00
20	0,85	8,83	3,40	1,00
21	0,00	0,76	2,83	1,00
22	0,85	1,07	1,86	1,00
23	0,00	0,07	1,28	1,00
24	1,48	0,69	0,70	1,00
25	0,99	0,07	0,57	1,00
26	0,00	0,00	0,30	1,00
27	0,67	0,00	0,44	1,00
28	0,00	0,00	0,20	1,00
29	0,00	0,00	0,45	1,00
30	0,00	0,00	0,14	1,00
31	0,00	0,00	0,21	1,00
32	0,00	0,00	0,00	1,00
33	0,00	0,00	0,04	1,00
34	0,00	0,00	0,02	1,00

5.13.4.1.3. Results including sensitivity analyses

This is the first assessment of hake in GSA 19. All results refer to the landed range of lengths/ages. Results show that, although longline and nets target big-sized hakes, exploitation is concentrated on recruits, age classes 0 and 1. Accordingly, the exploitation rate is very high and Y/R for nets and long line are very low. Also, F must be even higher than that shown in results, since no data on discards were used as input for the analysis but discard is know to occur. In fact, bottom trawl landings in 2007 and 2008 were much lower than in the previous years, while trawl fishing effort did not decrease.

Taking into account the input data used in the assessment (2006-2008 mean pseudo- cohort, no discards data, which means F values are underestimated) and that the data on fishing effort and landing do not correspond to a situation of equilibrium, these results are to be considered only as preliminary, and no management advice can be provided.

All results refer to the current state of exploitation.

Tab. 5.13.4.1.3.1 VIT assessment results.

	Total	Bottom trawl	Nets	Long line
Catch mean age (year)	1,159	1,149	1,151	2,599
Catch mean length (TL cm)	21,966	21,83	21,82	42,438
Mean F	1,173	0,653	0,207	0,314
Total catch (t)	1130,4	845,5	227,0	57,9

B/R	SSB/R	Y/R	Y/R Bottom trawl	Y/R Nets	Y/R Long line
35,536	10,476	86,524	64,718	17,376	4,43

---	Critical age	Critica length
Current stock	1,151	22
Virgin stock	2,343	40
Total Biomass balance (D):	1422332271,89	
---	Biomass	Percentage
Recruitment	372554720	26,19
Growth	1049777552	73,81
Natural death	291945322	20,53
Fishing	1130386950	79,47
R/B(mean)	63,37	
D/B(mean)	241,93	
B(max)/B(mean)	78,05	
B(max)/D	32,26	
Mean Mortality rate (Z)	1,369	
Mean Mortality rate (F)	1,105	

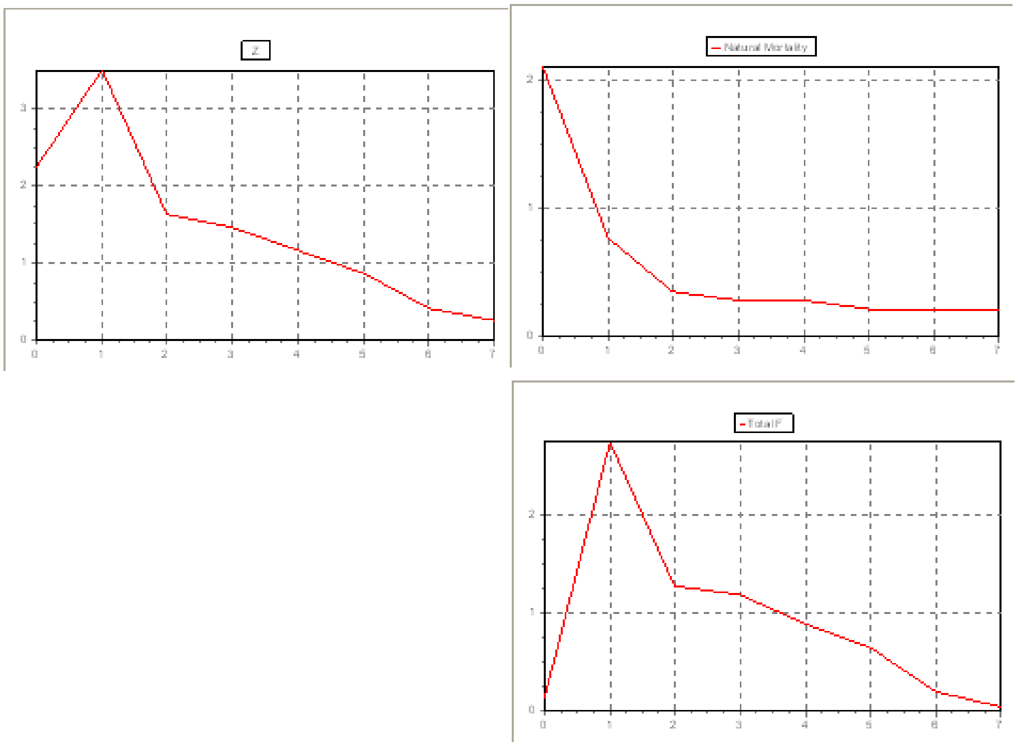


Fig. 5.13.4.1.3.1 VIT assessment results. GSA 19. *Merluccius merluccius*. Mortality rates: total (Z), natural (M), fishing (F)- bottom trawl, nets and longline combined.

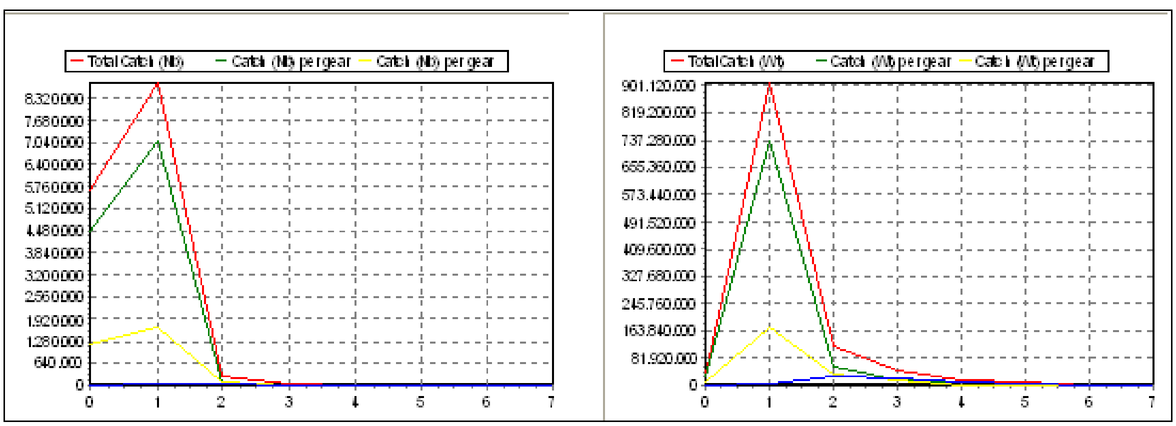


Fig. 5.13.4.1.3.2 VIT assessment results. GSA 19. *Merluccius merluccius.* VPA results, using VIT. Landings by fishing technique and age, in numbers (left) and weight (right). (red: total; green:bottom trawl; yellow: nets; blue: longline).

5.13.5. Long term prediction

5.13.5.1. Justification

The following analysis has been conducted by SGMED-09-02 in 2009. Yield per recruit analysis was performed, although, from data on landings and fishing effort during 2006-2008 and in the previous years, equilibrium conditions cannot be assumed. Thus, this analysis is presented only to provide a general overview of the exploitation of hake in GSA 19, and cannot be taken as a proposal for advice.

5.13.5.2. Input parameters

Input data are the exploitation pattern resulting for VPA (VIT) and its population parameters.

5.13.5.3. Results

Overall results of the yield per recruit analysis are given below.

Table 5.13.5.3.1. YpR results: column factor (x axis in the figure below), indicates the level of fishing effort regarding the current effort which would correspond to $F_{(0,1)}$, to the maximum Y/R for each gear, and for the three gears combined, as well as the current situation (Factor=1) and the situation in case the effort level was twice the current effort (Factor= 2).

	Factor	Y/R	B/R	SSB	Y/R OTB	Y/R NETS	Y/R L-LINE
F(0)	0	0	5,626,754	5,478,943	0	0	0
F(0.1)	0,15	252,575	2,013,164	1,907,635	108,730	37,949	105,896
Max L-Line	0,16	252,575	2,013,164	1,907,635	108,730	37,949	105,896
Max(all)	0,2	259,034	1,544,636	1,447,754	115,567	40,343	103,124
Max NETS	0,25	253,653	1,116,485	1,029,197	118,423	41,175	94,055
Max OTB	0,26	251,428	1,047,292	961,776	118,462	41,133	91,833
	1	86,524	35,536	10,476	64,718	17,376	4,430
	2	53,153	10,025	0,16	42,130	10,916	0,106

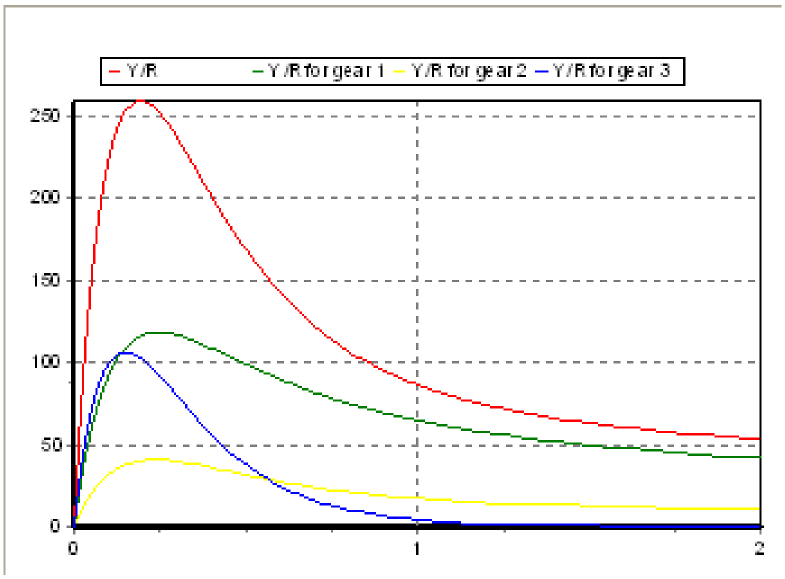


Fig. 5.13.5.3.1. GSA 19. *Merluccius merluccius*. Yield per recruit results (current effort= 1; red: total; green: bottom trawl; yellow: nets; blue: longline).

Yield per recruit results suggest a clear situation of overexploitation, for the three different fishing techniques targeting hake in GSA 19. F_{max} (F corresponding to the highest Y/R) is in all cases well below the current effort.

5.13.6. Scientific advice

5.13.6.1. Short term considerations

5.13.6.1.1. *State of the spawning stock size*

Survey results indicate a recent increase in stock abundance. However, due to the data deficiencies in the assessment and the lack of estimated limit or target management reference points, SGMED-10-02 is unable to fully review the status of the spawing stock.

5.13.6.1.2. *State of recruitment*

Survey results indicate a recent increase in stock abundance. Recent recruitment appears above average.

5.13.6.1.3. *State of exploitation*

Due to the data deficiencies in the assessment and the lack of estimated limit or target management reference points, SGMED-10-02 is unable to fully review the status of the exploitation. However, the persistent lack of older fish in the surveyed population and catches indicate high exploitation rates in the period 2006 to 2008 far in access of any sustainable level.

5.14. Stock assessment of hake in GSA 20

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.14.1. Stock identification and biological features

5.14.1.1. Stock Identification

Hake is one of the most important fish stocks in GSA 20 for bottom trawlers, nets (mainly gill nets) and longlines. The stock is distributed in depth between 50-600 m, with a peak in abundance in depths between 200 and 300 m. The stock is exploited almost exclusively by the Greek fishing fleet. Spawning takes place all year round, with a peak during winter – spring.

5.14.1.2. Growth

No information was documented during SGMED-10-02.

5.14.1.3. Maturity

No information was documented during SGMED-10-02.

5.14.2. Fisheries

5.14.2.1. General description of fisheries

Hake mainly lives on muddy substrates in depths between 50-600 m. The main landing port in the area is the port of Patra. Other important landing ports are in Igoumenitsa, Kerkyra, Preveza, Killini and Kalamata.

The bottom trawl fishery in Greece is a mixed fishery, operating 24hr per day. Bottom trawl fishing targeting hake, is taking place mainly during the day in muddy bottoms in depths 80-400 m (approximately). The mesh size of the cod end of bottom trawls is 40 mm. Apart from hake, important target species are shrimps, anglerfish, blue whiting, megrims, picarel and red mullet.

The gill nets are setting in the morning and are hauling the next day in depth from 80-300 m. The mesh size used is about 48 to 64 mm. The fishery is carried out mainly during summer when bottom trawl fishery is closed. Long line fishery for hake is taking place in deeper waters down to 500 m mainly during summer. Fishing is taking place during the day. The size of the hook is No 6-8. Gillnet and especially longline fisheries have a relatively greater species and size selectivity. The main by catch species in the gill net fishery is horse mackerel.

Due to the selectivity of each gear the length composition differs significantly. The catch from bottom trawls consists mainly of small individuals (hake with lengths between 6 and 18 cm are ~75% of the catch by number). The catch of gill nets comprises mainly of specimens with lengths between 20 and 40 cm, while longliners catch relatively large fish.

5.14.2.2. Management regulations applicable in 2009 and 2010

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone one and a half mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1st of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2008, the net shall be replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the shipowner, by a diamond meshed net of 50 mm.

Additional restrictions exist for bottom trawling in specific areas: in Amvrakikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1st of March till the end of November.

The operation of the bottom set nets is subject to the following main restrictions:
(1) the maximum total length of the trammel net is 6000 m.
(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2,500 m.

5.14.2.3. Catches

5.14.2.3.1. Landings

Estimation of landings was based on random sampling in 66 sampling stations (ports) in GSA 20. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type was randomly selected and landings by species recorded. Based on these data, average landings per fishing day, by species and for each fishing gear were estimated. Based on total effort estimations, sampled data were raised to the whole fleet to estimate total landings by species, fleet segment, fishing gear, and GSA.

Tab. 5.14.2.3.1.1 shows the trend in reported landings taken by major gear types. The data were reported to SGMED-09-02 in 2009 through the Data Collection Regulation. No data were reported by Greece in 2010.

Tab. 5.14.2.3.1.1 Greek landings (t) by year and major gear types, 2002-2008 as reported through DCF.

SPECIES	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
HKE	20	GRC	FPO							4
HKE	20	GRC	GTR		1445	3112	3404	2768		2545
HKE	20	GRC	LLS							286
HKE	20	GRC	OTB		308	404	516	754		459
HKE	20	GRC	PS			1				
HKE	20	GRC	SB		12	4	1			

5.14.2.3.2. Discards

No discards data were reported to SGMED-09-02 and SGMED-10-02 through the DCF data calls for Greece.

5.14.2.3.3. Fishing effort

Estimation of effort was based on interviews conducted with random sampling in 30 sampling stations (ports) in GSA 20. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive and the proportion of the year when they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, fishing gear, and GSA. Should be noted that the estimated effort do not refer to the effective effort targeting to hake but to the entire effort of each fleet segment. This is very important for the long lines and gill nets because the effort targeting hake is much smaller than the effort of the fleets.

Tab. 5.14.2.3.3.2 lists the fishing effort reported to SGMED-09-02 through the DCR data call. No effort data were reported by Greece in 2010.

Tab. 5.14.2.3.3.2 Fishing effort in different units by fishing technique deployed in GSA 20, 2003-2008.

TYPE	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DAYS	20	GRC	GTR		838891	749522	777934	688042		574268
DAYS	20	GRC	LLS		1212	6333	3843	11810		99755
DAYS	20	GRC	OTB		7810	7296	6279	6682		6753
DAYS	20	GRC	PS		5386	4646	6132	5559		5197
DAYS	20	GRC	SB		13429	11118	10883	11363		12774
GT*DAYS	20	GRC	GTR		3338474	2974825	2949967	2509455		2264227
GT*DAYS	20	GRC	LLS		9110	43698	26517	81492		396520
GT*DAYS	20	GRC	OTB		574443	580133	435054	565011		534692
GT*DAYS	20	GRC	PS		105429	123580	230265	189582		155249
GT*DAYS	20	GRC	SB		83099	65507	58441	57058		75249
KW*DAYS	20	GRC	GTR		33001422	25547517	24809229	19460968		18504513
KW*DAYS	20	GRC	LLS		125676	698284	423729	1302215		3486777
KW*DAYS	20	GRC	OTB		2374841	2359179	1729664	2024955		1800736
KW*DAYS	20	GRC	PS		725384	874064	747375	626335		615159
KW*DAYS	20	GRC	SB		863066	697644	604098	623628		807597

5.14.3. Scientific surveys

5.14.3.1. Medits

5.14.3.1.1. Methods

Tables TA, TB, TC were provided according to the MEDITS protocol. The MEDITS survey was carried out in GSA 20 every summer from 1994 to 2008, except in 2002 because of administrative problems. For similar reasons, no MEDITS survey was conducted in Greece in 2007. During 1994 and 1995 the survey in GSA 20 was carried out in a small number of stations (12 and 15). The number of stations kept increasing and in 1998 was more than doubled (32 stations). The survey vessel changed in 1998. Due to these changes in the survey design, caution is needed when investigating the trends of relevant indicators in the MEDITS time series. More details on methodology and trends on selected indicators may be found in MEDITS (2007).

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 20 the following number of hauls was reported per depth stratum (s. Tab. 5.14.3.1.1.1).

Tab. 5.14.3.1.1.1. Number of hauls per year and depth stratum in GSA 20, 1994-2008.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA20_010-050	2	2	2	2	4	3	3	3		3	3	3	3		3	
GSA20_050-100	3	4	8	7	11	10	11	9		10	10	10	9		10	
GSA20_100-200	1	3	4	2	5	6	5	6		6	6	5	6		6	
GSA20_200-500	2	3	4	4	7	7	7	8		8	9	8	8		7	
GSA20_500-800	3	2	4	3	5	5	5	5		5	3	5	4		6	

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.14.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.14.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 20 was derived from the international survey Medits. Figure 5.14.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 20.

The estimated abundance and biomass indices reveal a significantly increased level of stock size since 2003. However, the recent abundance and biomass indices are subject to high variation (uncertainty). The analyses of Medits indices are considered preliminary.

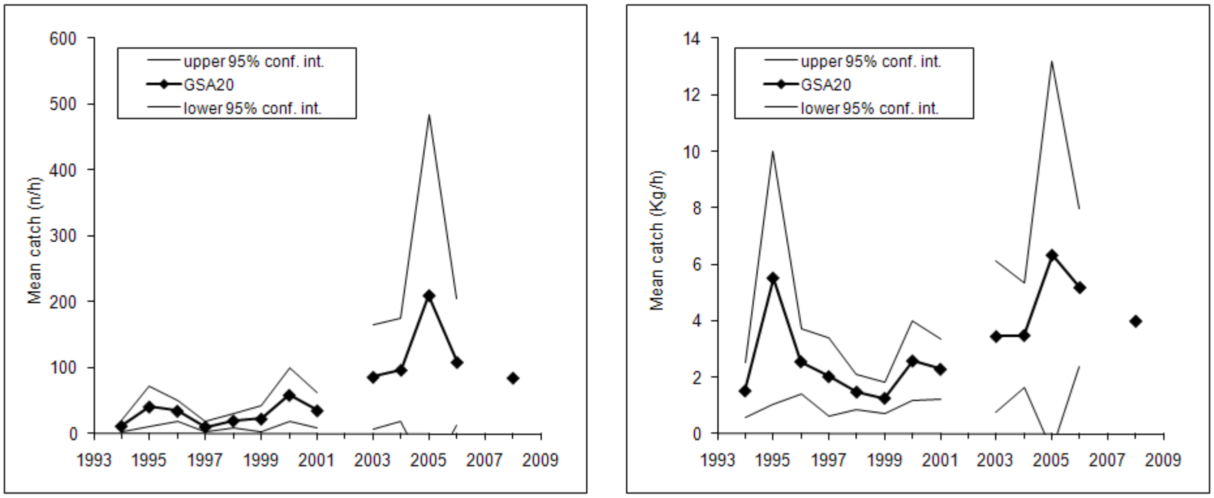


Fig. 5.14.3.1.3.1 Abundance and biomass indices of hake in GSA 20.

5.14.3.1.4. Trends in abundance by length or age

The following Fig. 5.14.3.1.4.1 and 2 display the stratified abundance indices of GSA 20 in 1994-2001 and 2003-2008.

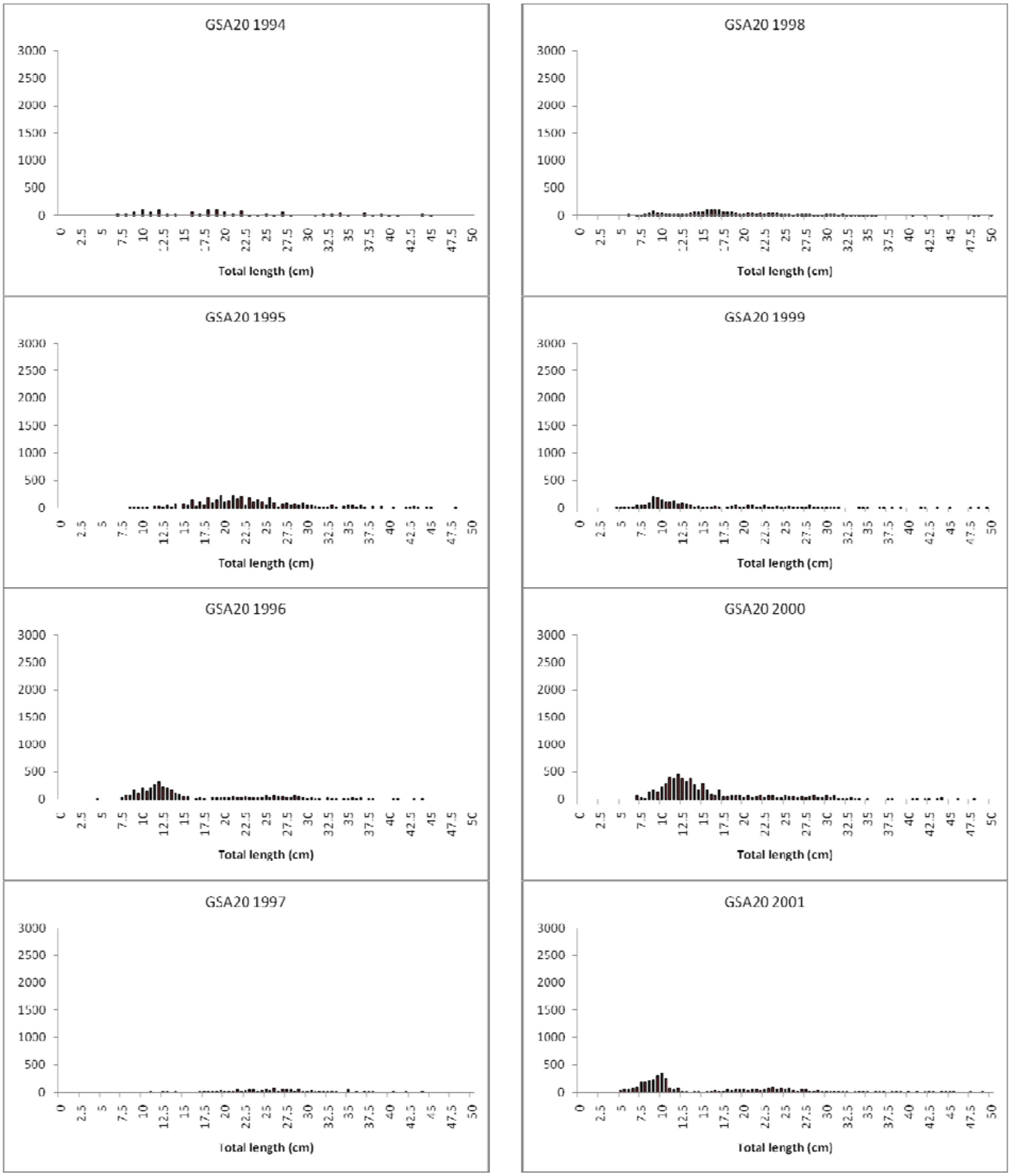


Fig. 5.14.3.1.4.1 Stratified abundance indices by size, 1994-2001.

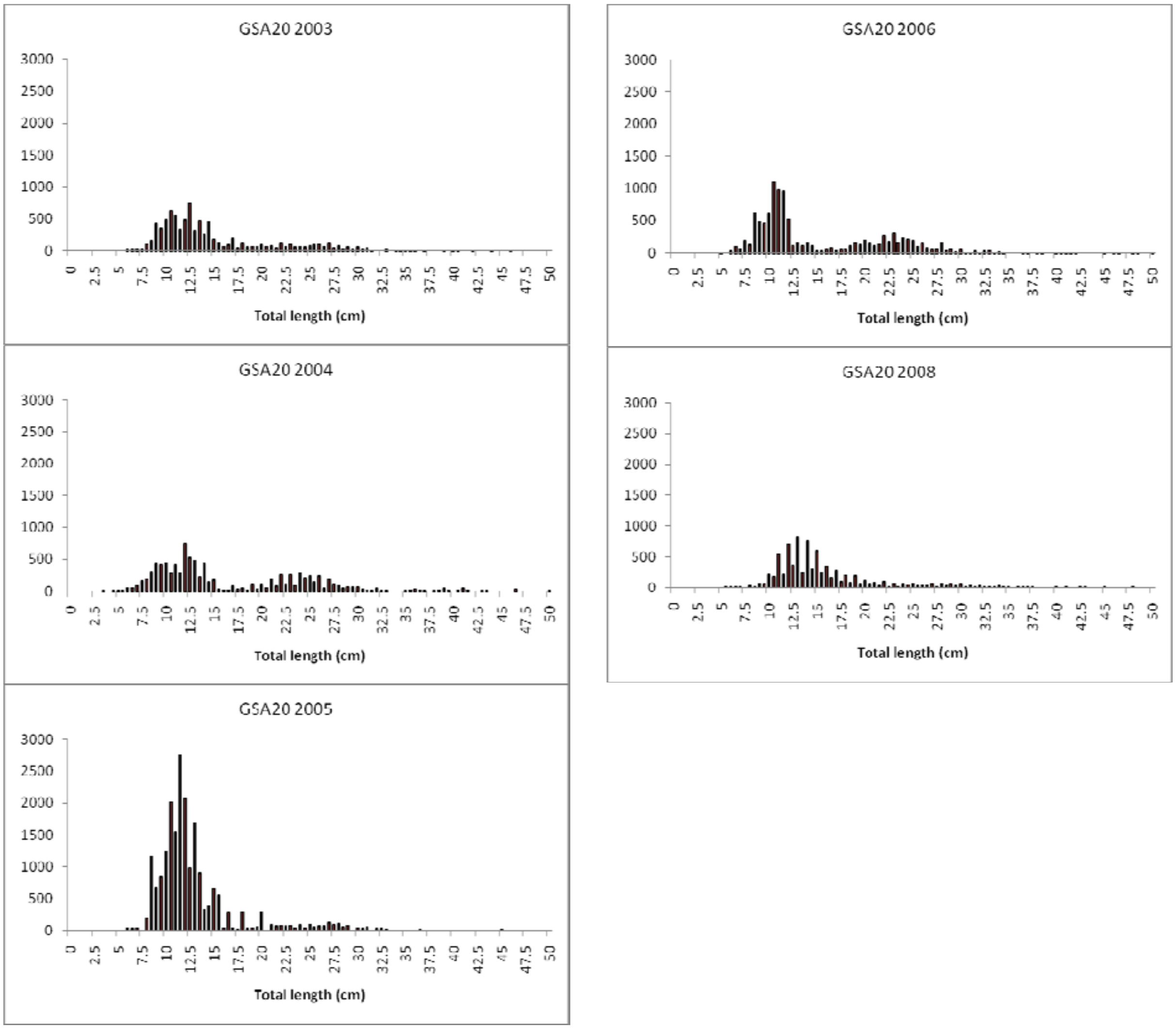


Fig. 5.14.3.1.4.2 Stratified abundance indices by size, 2003-2008.

5.14.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.14.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.14.4. Assessment of historic stock parameters

SGMED 10-02 did not undertake any analytical assessment of hake in GSA 20. A preliminary assessment using SURBA can be found in the report of SGMED-08-04 working group (Cardinale et al., 2008).

5.14.5. Long term prediction

5.14.5.1. Justification

No forecast analyses were conducted.

5.14.5.2. Input parameters

No forecast analyses were conducted.

5.14.5.3. Results

No forecast analyses were conducted.

5.14.6. Scientific advice

5.14.6.1. Short term considerations

5.14.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.14.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.14.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.15. Stock assessment of hake in GSAs 22 and 23 combined

5.15.1. Stock identification and biological features

5.15.1.1. Stock Identification

Hake is one of the most commercially important fish in GSAs 22-23 and the stock is exploited by bottom trawls, nets (mainly gillnets) and longlines. The stock is mainly distributed in depth between 50-600 m, with a peak in abundance in depths between 200 and 300 m. The stock is exploited by the Greek and Turkish fishing fleets. Spawning occurs all year around, with a peak during winter - spring.

5.15.1.2. Growth

No information was documented during SGMED-10-02.

5.15.1.3. Maturity

No information was documented during SGMED-10-02.

5.15.2. Fisheries

5.15.2.1. General description of fisheries

Hake mainly inhabits muddy substrates in depths between 50-600 m. The main Greek landing ports in the GSAs 22-23 are those of Pireaus, Thessaloniki, Kavala, Alexandroupolis, Volos, Chalkida and Chios.

The bottom trawl fishery in Greece is a mixed fishery, operating from the beginning of October until the end of May, as a 4-month fishery closure (June-September) for bottom-trawlers is enforced by national and EC legislation. The minimum mesh size of the cod end of bottom trawls is 40 mm.

The mesh size of gillnets ranges from 48 to 64 mm. The fishery is carried out mainly during summer when bottom trawl fishery is closed. Long line fishery for hake is taking place in deeper waters down to 500 m mainly during summer. Longline fisheries target individuals of greater size than the other gears.

Due to the different selectivity the length composition differs significantly among gears. Individuals belonging to year classes 0-3 compose the main bulk of bottom trawl catches.

5.15.2.2. Management regulations applicable in 2009 and 2010

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone 1.5 mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1st of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2008, the net should have been replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship-owner, by a diamond meshed net of 50 mm. So far, only a few boats have actually replaced their nets.

Several additional restrictions exist for bottom trawling in specific areas. For example in Amvrakikos Gulf, Pagassitikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1st of March till the end of November.

The operation of the bottom set nets is subject to the following main restrictions:

(1) the maximum total length of the trammel net is 6000 m.
(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2,500 m.

5.15.2.3. Catches

5.15.2.3.1. Landings

Estimation of landings was based on random sampling in 127 sampling stations (ports) in GSA 22-23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and landings by species recorded. Based on these data, average landings per fishing day, by species and for each fishing gear were estimated. Based on total effort estimations, sampled data were raised to the whole fleet to estimate total landings by species, fleet segment, fishing gear and GSA.

Tab. 5.15.2.3.1.1 shows the trend in reported landings taken by major gear types. The data were reported to SGMED-09-02 in 2009 through the Data Collection Regulation. No data in 2010 were submitted.

Tab. 5.15.2.3.1.1 Greek landings (t) by year and major gear types, 2002-2008 as reported through DCF.

SPECIES	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
HKE	22+23	GRC	FPO							0
HKE	22+23	GRC	GTR		2507	4039	4649	5229		2612
HKE	22+23	GRC	LLS		22	16	90			747
HKE	22+23	GRC	OTB		2444	3572	3857	3835		3793
HKE	22+23	GRC	PS		0	3				
HKE	22+23	GRC	SB		13	5	7	15		8

5.15.2.3.2. Discards

No discards data were reported to SGMED-10-02 through the DCF data call for Greece.

5.15.2.3.3. Fishing effort

Estimation of effort was based on interviews conducted with random sampling in 127 sampling stations (ports) in GSA 22-23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive, and the proportion of the year they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, fishing gear, and GSA. It should be noted that the estimated effort do not refer to the effective effort targeting to hake but to the entire effort of each fleet segment. This is very important for the long lines and gill nets because the effort targeting hake is much smaller than the effort of the fleets.

Tab. 5.15.2.3.3.1 lists the fishing effort reported in 2009 through the DCR data call.

Tab. 5.15.2.3.3.1 Fishing effort in different units by fishing technique deployed in GSAs 22 and 23, 2003-2008. No data were reported in 2010.

TYPE	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DAYS	22	GRC	GTR		2078058	1908626	1993815	1914951		1374948
DAYS	22	GRC	LLS		20905	41155	41568	51501		302098
DAYS	22	GRC	OTB		52536	53381	56580	53367		51855
DAYS	22	GRC	PS		44481	43772	48211	42874		40029
DAYS	22	GRC	SB		36266	31987	33200	30098		25138
GT*DAYS	22	GRC	GTR		8567144	8034837	7939836	7571041		5309125
GT*DAYS	22	GRC	LLS		332005	577572	603419	780138		1244484
GT*DAYS	22	GRC	OTB		4927349	4972085	5553804	5556446		5355704
GT*DAYS	22	GRC	PS		1998124	1987556	2295466	2108039		1930332
GT*DAYS	22	GRC	SB		294896	269645	276265	257271		214985
KW*DAYS	22	GRC	GTR		68845607	70633794	70746878	66780942		50244080
KW*DAYS	22	GRC	LLS		1888201	4977272	2715667	3848302		7914684
KW*DAYS	22	GRC	OTB		15792715	15874762	17730748	16424382		16013057
KW*DAYS	22	GRC	PS		9389351	9140980	9656463	8992650		8233643
KW*DAYS	22	GRC	SB		2775797	2206815	2193550	2022231		1774864

5.15.3. Scientific surveys

5.15.3.1. Medits

5.15.3.1.1. Methods

The MEDITS survey was carried out in GSAs 22-23 every summer from 1994 to 2008, except in 2002, 2007 and 2009 because of administrative problems. In GSA 22 and 23, the number of stations was 98 in 1994 and gradually increased to 146 in 1996 and onwards. Due to this change in the survey design, caution is needed when investigating the trends of relevant indicators in the MEDITS time series unless the data are properly standardised. More details on methodology and trends on selected indicators may be found in MEDITS (2007).

Based on the DCR data call, abundance and biomass indices were calculated. In GSAs 22 and 23 the following number of hauls was reported per depth stratum (Tab. 5.15.3.1.1.1).

Tab. 5.15.3.1.1.1. Number of hauls per year and depth stratum in GSAs 22 and 23, 1994-2008. No survey was conducted in 2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GSA22+23_010-050	10	10	11	10	13	12	13	13		13	13	14	14		13
GSA22+23_050-100	19	21	22	28	24	26	21	25		25	23	24	24		27
GSA22+23_100-200	19	26	38	36	36	33	38	35		36	43	41	41		40
GSA22+23_200-500	32	35	45	50	51	54	50	48		51	53	52	52		52
GSA22+23_500-800	18	13	19	22	22	21	20	17		17	17	17	17		17

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai) / A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = $Yst \pm t(\text{student distribution}) * V(Yst) / n$

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.15.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.15.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of hake in GSAs 22 and 23 was derived from the international survey MEDITS. Fig. 5.15.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSAs 22 and 23. The estimated abundance and biomass indices show an increasing trend since 2003.

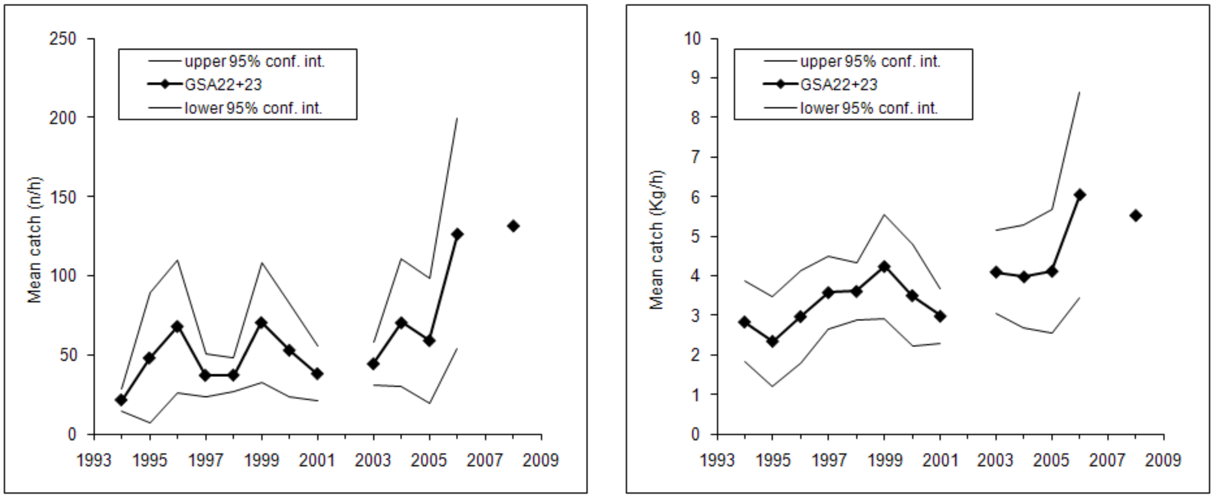


Fig. 5.15.3.1.3.1 Abundance and biomass indices of hake in GSAs 22 and 23.

5.15.3.1.4. Trends in abundance by length or age

The following Fig. 5.15.3.1.4.1 and 2 display the stratified abundance indices of GSAs 22and 23 combined in 1994-2001 and 2003-2008. These size compositions are considered preliminary.

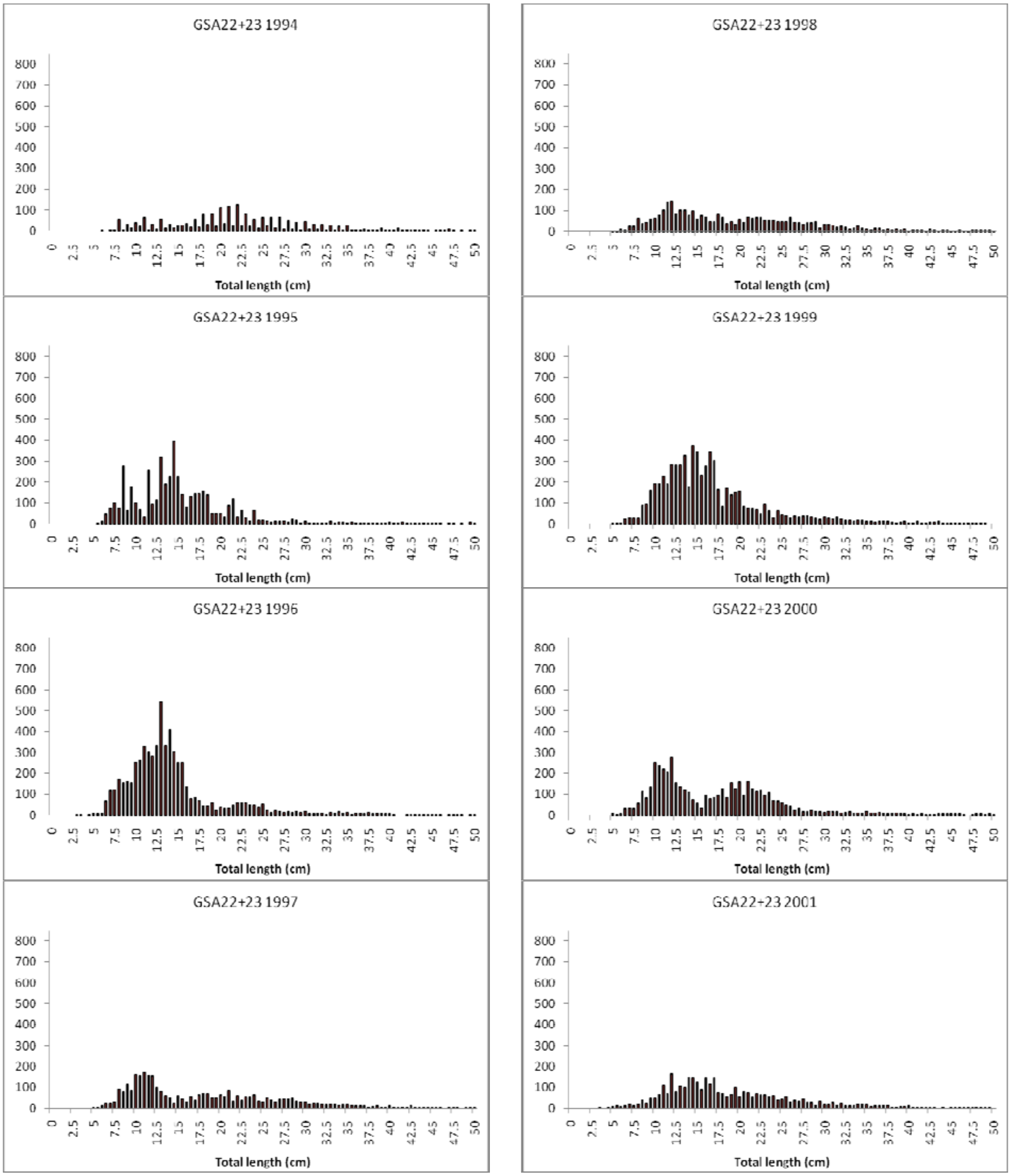


Fig. 5.15.3.1.4.1 Stratified abundance indices by size, 1994-2001.

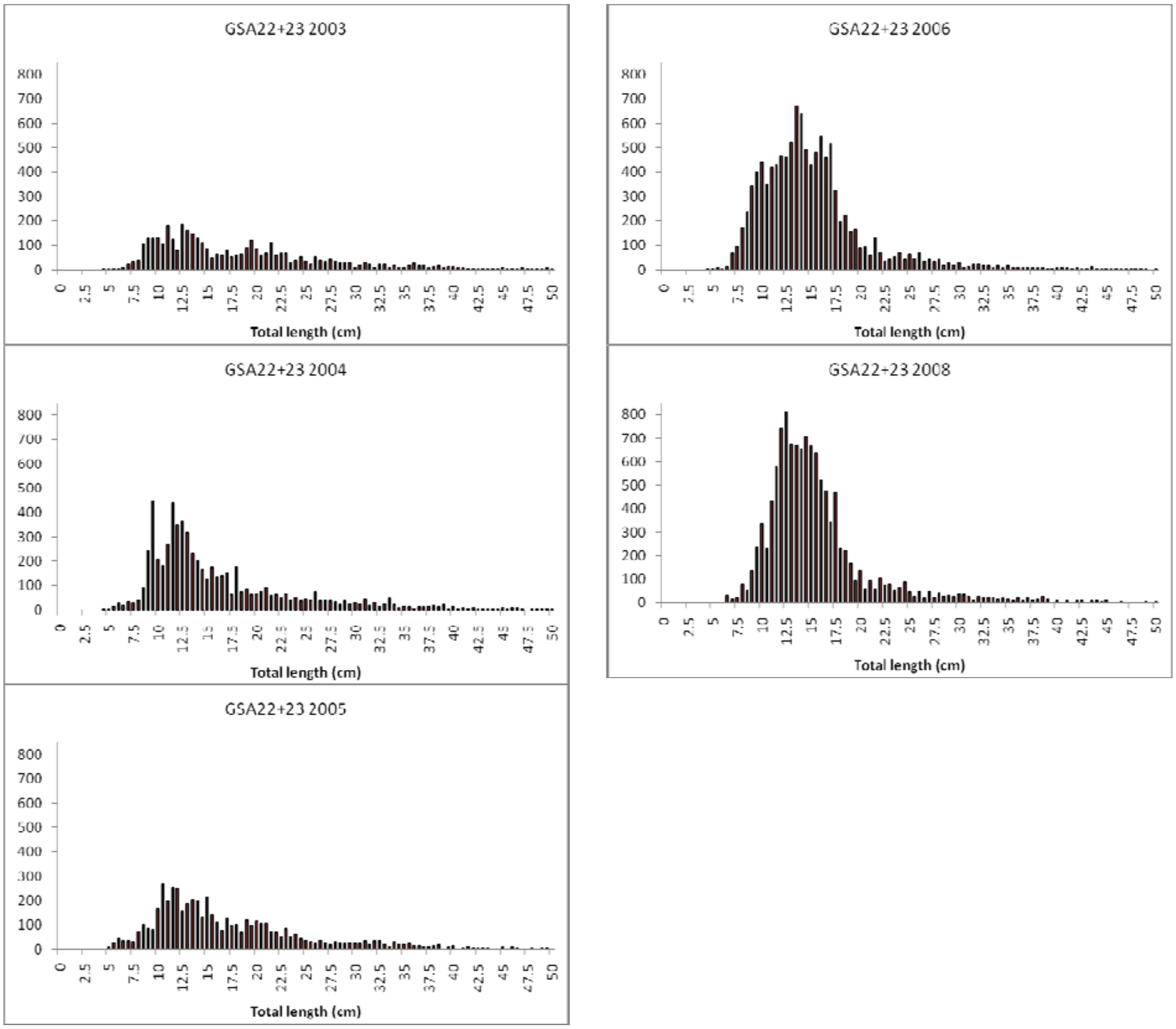


Fig. 5.15.3.1.4.2 Stratified abundance indices by size, 2003-2008.

5.15.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.15.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.15.4. Assessment of historic stock parameters

Two new assessments are presented based on surplus production and yield per recruit analysis. Age-based assessments could not be carried out due to lack of sufficient catch-at-age information. Attempts to analyse MEDITS survey data through the SURBA software failed as not proper model fitting was achieved.

5.15.4.1. Method 1: Surplus production model

5.15.4.1.1. Justification

The assessment of the hake (*Merluccius merluccius*) stock was based on the logistic surplus production model (Schaefer 1954) using a non-equilibrium approach which utilizes a time series of CPUE and landings data (Tserpes, 2008).

The model is described below:

For a given *r* value the following approach has been followed:

1. Estimation of harvest rate for the beginning of the period

$$hr = \frac{F}{Z} \times (1 - e^{-Z})$$

2. Estimation of initial biomass fraction (i.e. B/k)

$$B_{fr} = 1 - \frac{hr}{r}$$

3. Estimation of a starting *k* value

$$k_{in} = \frac{C_{av} \times 4}{r}$$

(assumes that average catch is around to MSY).

4. Estimation of initial biomass

$$B_0 = B_{fr} \times k_{in}$$

5. Estimation of a starting *q* value

$$q_{in} = \frac{U_{av}}{B_0}$$

(U_{av}=mean abundance index)

6. Final estimates of model parameters *(k, q)* were obtained using a least squares criterion of fit assuming log-normally distributed residual errors between observed and expected abundance indices.

The equations used were:

$$B_t = B_{t+1} + rB_{t-1}(1 - \frac{B_{t-1}}{k}) - C_{t-1}$$

$$U_t = q \times B_t$$

$$\varepsilon_t = (\log U_t - \log \hat{U}_t)^2$$

$$U_t = (B_{t-1} + rB_{t-1}(1 - \frac{B_{t-1}}{k}) - C_{t-1}) \times q$$

The above steps have been repeated for a series of consecutive r values (range 0.30-0.99, interval 0.01). As the best model, was considered that providing the lowest error and its parameters were used to calculate population biomass time series as well as equilibrium MSY, B_{msy} and F_{msy} rates. Confidence intervals were estimated through bootstrapping. Model estimates were made by means of computer code developed in R-language.

5.15.4.1.2. Input parameters

The following data were used as input for the model:

Total Aegean landings by year for the period 1990-2006 were extracted from National Statistical Service of Greece (NSSG) database and reconstructed to include small scale coastal fisheries catches based on the approach by Tsikliras et al. (2007) (Table 5.15.4.1.2.1.). Greek landings are the only data appearing in GFCM dataset for GSA 22-23.

Table 5.15.4.1.2.1. Hake Aegean landings (in kg) for the period 1990-2006.

Year	**Landings (kg)**
1990	3629909
1991	3187166
1992	3884366
1993	4588430
1994	5681519
1995	5520918
1996	4899280
1997	4546963
1998	3792639
1999	3688741
2000	3535997
2001	3370717
2002	3512077
2003	3697037
2004	4166477
2005	4264560
2006	5003280

A yearly index of MEDITS CPUE series for the period 1996-2006 (excluding 2002 for which no data were available) based on data from the MEDITS project for GSA 22+23 (www.ifremer.fr/Medits_indices) (Table 5.15.4.1.2.2.).

Table 5.15.4.1.2.2. Hake in GSA 22+23. MEDITS CPUE index for 1996-2006.

Area	Year	CPUE index
22	1996	39.860
22	1997	50.577
22	1998	45.493
22	1999	51.045
22	2000	49.994
22	2001	35.789
22	2002	-
22	2003	53.252
22	2004	51.454
22	2005	45.737
22	2006	59.538

5.15.4.1.3. Results

The best fit was provided for r = 0.66 (0.47-0.85) and k=25187 t (19299-32337). Based on the above estimates, equilibrium MSY was 4254 t (Figure 5.15.4.1.3.1) and the corresponding rates for fishing mortality and biomass were: F_{MSY} =r/2 = 0.33 and B_{MSY} =k/2= 12593 t. Annual catches in the latest years are slightly exceeding MSY, while stock biomass levels are increasing in the last decade being close to B_{MSY} (Figure 5.15.4.1.3.2). CPUE shows an increasing trend since 2001 (Figure 5.15.4.1.3.3).

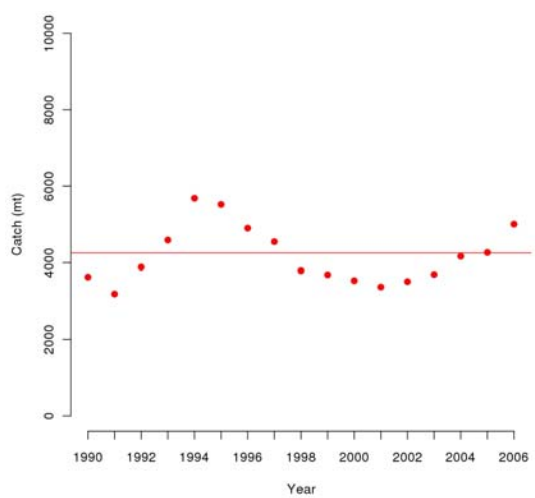


Figure 5.15.4.1.3.1. Hake catch by year (red points) and MSY levels (red horizontal line).

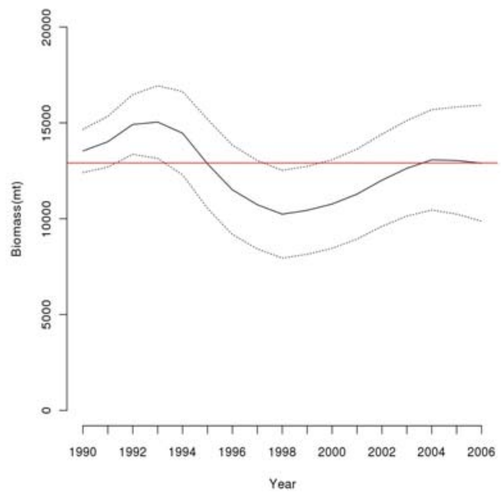


Figure 5.15.4.1.3.2. Hake biomass (black solid line) by year and B_{MSY} levels (red horizontal line).

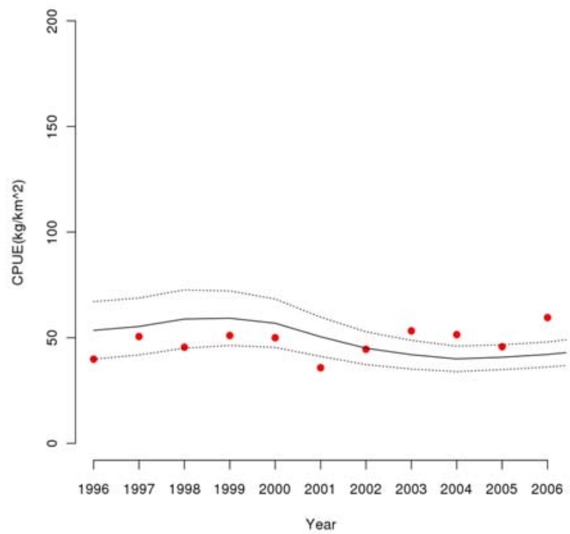


Figure 5.15.4.1.3.3. Hake CPUE by year (red points) and model fitted line.

5.15.5. Long term prediction

5.15.5.1. Justification

A Y/R analysis was conducted using the Yield software.

5.15.5.2. Input parameters

Growth parameters

L_8	100
k	0.25
to	-0.35

Weight-length relationship

a (W-L)	0.0000035
b (W-L)	3.196

Natural mortality	0.4
Age at maturity	1
Age at first capture	0.6

5.15.5.3. Results

Table 5.15.5.3.1 lists the reference points estimated from the yield per recruit analysis.

Table 5.15.5.3.1 Fisheries management reference values derived from yield per recruit analysis.

F_{max}	0.31
$F_{0.1}$	0.20

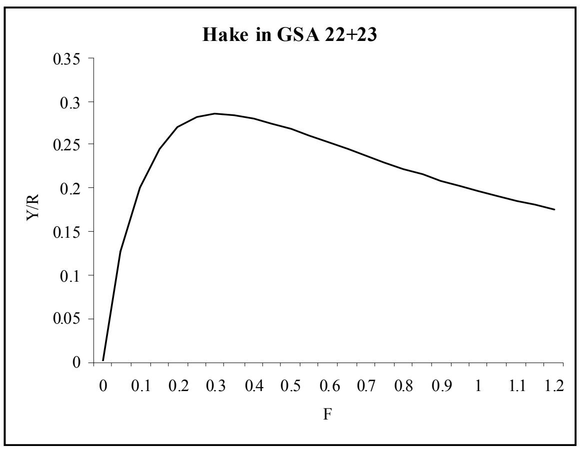


Fig. 5.15.5.3.1 YpR with increasing F.

5.15.6. Data quality

The lack of catch-at-age data did not allow the use of an age-based assessment that would provide a more detailed and robust information about the stock status. Fisheries data from the eastern Aegean coast would have been useful but no hake landings appear in the GFCM dataset from Turkey, with only a few exceptions of reporting very low landings (1993, 1997, 1998). SGMED notes that due to lack of recent data, the assessment relies on data up to 2006. Thus, SGMED is not able to carry out a more recent assessment of the stock. Also, SGMED considers that the interruption of the survey time series and the lack of catch and weight at age data from the landings will preclude the assessment and management of hake in GSA 22+23 in the next years.

5.15.7. Scientific advice

SGMED-10-02 considers all analyses presented to assess the status of hake in GSAs 22 and 23 as preliminary and not suitable to provide sound scientific advice. Moreover, the lack of data from 2007 and onwards preclude a more recent assessment of the status of the stock.

5.15.7.1. Short term considerations

5.15.7.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.15.7.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.15.7.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation in relation to proposed precautionary and target levels given the preliminary state of the data and analyses.

5.16. Stock assessment of red mullet in GSA 01

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.16.1. Stock identification and biological features

5.16.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.16.1.2. Growth

No information was documented during SGMED-10-02.

5.16.1.3. Maturity

No information was documented during SGMED-10-02.

5.16.2. Fisheries

5.16.2.1. General description of fisheries

STECF (Consolidated Advice on Stocks of Interest to the European Community) notes that red mullets are of the most important target species for the trawl fisheries but are also caught with set gears, in particular trammel-nets and gillnets. From official data, the total trawl fleet of the geographical sub-area 01 (Northern Alboran Sea region) is composed by about 170 boats: on average, 42 TRB, 60 GT and 197 HP (in 2007). Smaller vessels operate almost exclusively on the continental shelf (targeted to red mullets, octopuses, hake and sea breams), bigger vessels operate almost exclusively on the continental slope (targeted to decapod crustaceans) and the rest can operate indistinctly on the continental shelf and slope fishing grounds. Red mullet is intensively exploited during its recruitment from August to November.

5.16.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.16.2.3. Catches

5.16.2.3.1. Landings

Landings data were reported to SGMED-10-02 through the Data collection regulation. Only landings by otter trawlers are considered, which increased from 68 t in 2002 to 154 t in 2009.

Table 5.16.2.3.1.1 Annual landings (t) by fishing technique as reported to SGMED-10-02 through the DCR data call.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	1	ESP	OTB	DEMSP	40D50	68	81	109	94	109	138	113	154

5.16.2.3.2. Discards

No information was documented during SGMED-10-02.

5.16.2.3.3. Fishing effort

No fishing effort data were provided to SGMED-10-02.

5.16.3. Scientific surveys

5.16.3.1. Medits

5.16.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 01 the following number of hauls were reported per depth stratum (s. Tab. 5.16.3.1.1.1).

Tab. 5.16.3.1.1.1. Number of hauls per year and depth stratum in GSA 01, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA01_010-050	2	1	2	2	2	2	2	3	3	3	3	2	3	3	4	2
GSA01_050-100	5	4	5	5	5	7	6	4	6	10	7	7	6	6	6	7
GSA01_100-200	3	3	3	5	5	5	5	4	8	6	5	6	5	6	6	6
GSA01_200-500	7	9	11	10	7	11	12	10	11	11	13	11	11	11	11	11
GSA01_500-800	6	9	12	10	12	12	9	13	13	14	13	11	15	10	7	5

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA

Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.16.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.16.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 01 was derived from the international survey Medits. Figure 5.16.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 01.

The estimated abundance and biomass indices do not reveal any significant trends since 1994. However, the recent abundance and biomass indices since 2004 appear high but are subject to high variation (uncertainty).

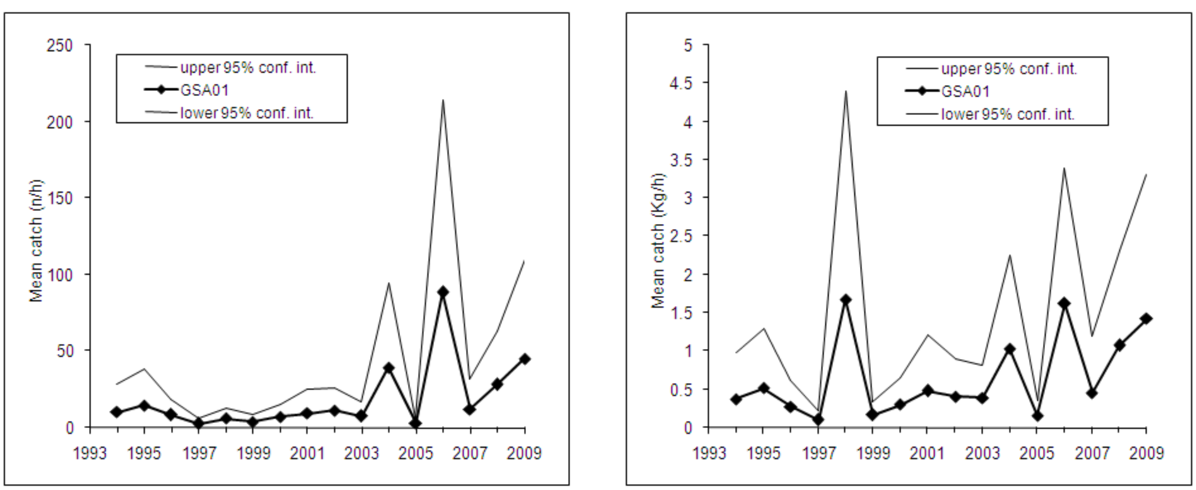


Fig. 5.16.3.1.3.1 Abundance and biomass indices of red mullet in GSA 01.

5.16.3.1.4. Trends in abundance by length or age

The following Fig. 5.16.3.1.4.1 and 2 display the stratified abundance indices of GSA 01 in 1994-2001 and 2002-2009.

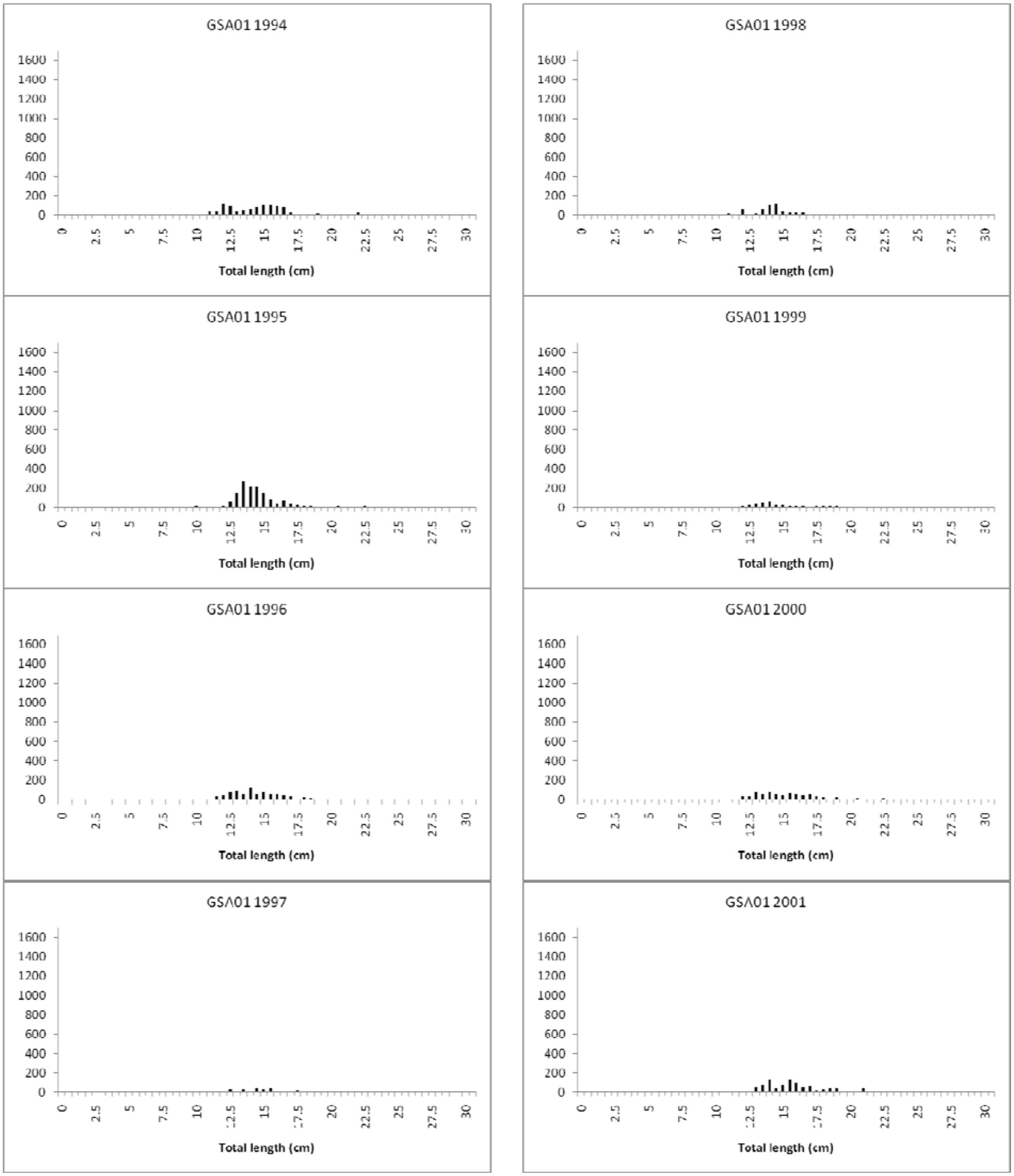


Fig. 5.16.3.1.4.1 Stratified abundance indices by size, 1994-2001.

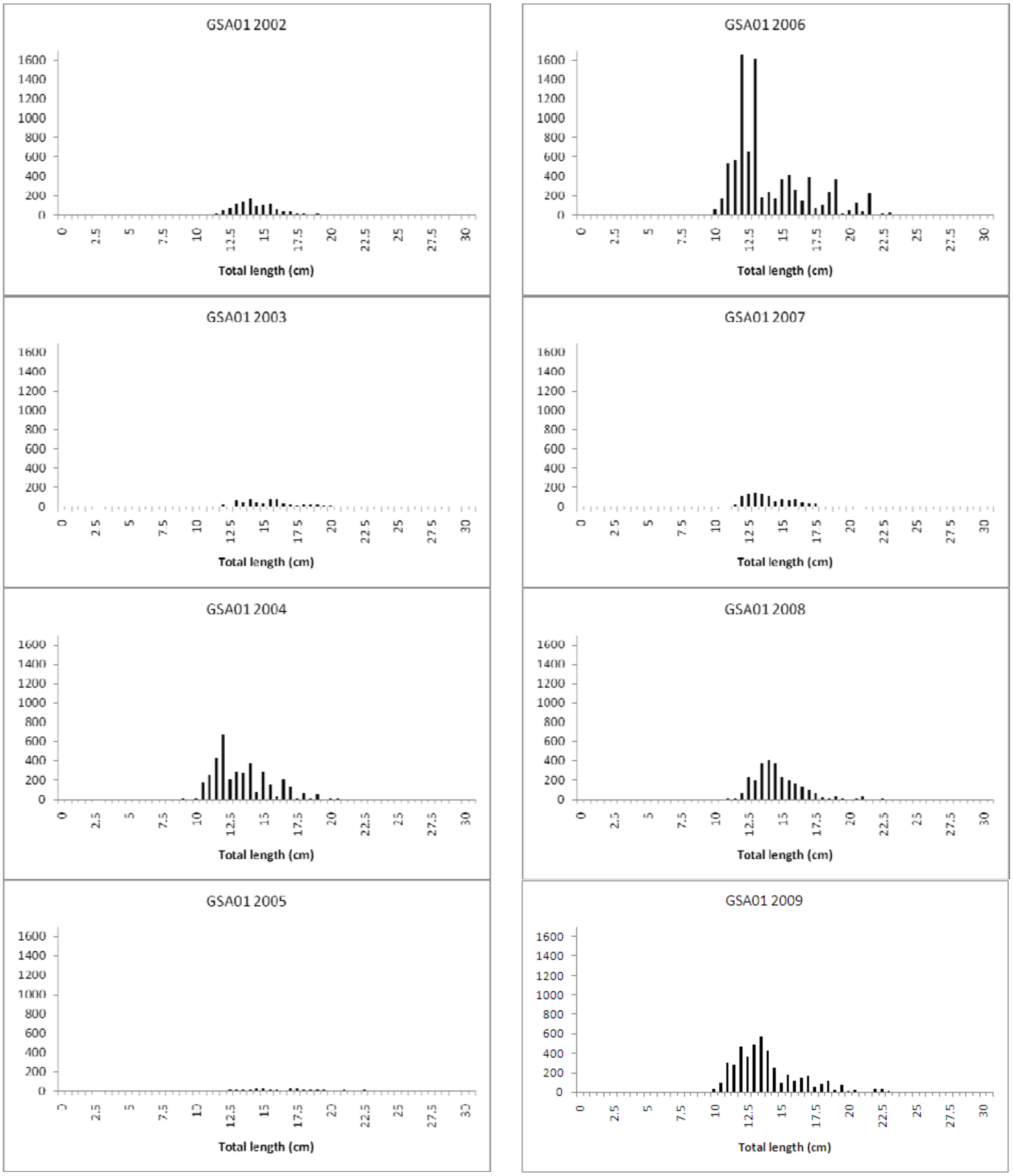


Fig. 5.16.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.16.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.16.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.16.4. Assessment of historic stock parameters

SGMED 10-02 did not undertake any analytical assessment of red mullet in GSA 01. An assessment using VIT can be found in the report of SGMED-08-04 working group (Cardinale et al., 2008).

5.16.5. Long term prediction

5.16.5.1. Justification

No forecast analyses were conducted.

5.16.5.2. Input parameters

No forecast analyses were conducted.

5.16.5.3. Results

No forecast analyses were conducted.

5.16.6. Scientific advice

5.16.6.1. Short term considerations

5.16.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.16.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.16.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation in relation to proposed precautionary and target levels given the preliminary state of the data and analyses.

5.17. Stock assessment of red mullet in GSA 05

5.17.1.1.Stock identification and biological features

Due to the lack of information about the structure of red mullet (*Mullus barbatus*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 05 boundaries.

5.17.1.2. Stock Identification

No analyses were conducted during SGMED-10-02.

5.17.1.3. Growth

No analyses were conducted during SGMED-10-02.

5.17.1.4. Maturity

No analyses were conducted during SGMED-10-02.

5.17.2. Fisheries

5.17.2.1. General description of fisheries

In the Balearic Islands (GSA 5), commercial trawlers employ up to four different fishing tactics (Palmer et al. 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Guijarro & Massutí 2006; Ordines et al. 2006). Vessels mainly target striped red mullet (*Mullus sumuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered monospecific.

The two species of red mullet inhabiting the Mediterranean, *Mullus surmuletus* and *M. barbatus*, are present in the GSA 5. However, *M. surmuletus* predominates in this area where the species is targeted by both the artisanal and trawl fleet working along the continental shelf. On the contrary, *M. barbatus* is exclusively caught as a by-catch species by trawlers operating mainly on the deep shelf.

5.17.2.2. Management regulations applicable in 2009 and 2010

Fishing license: fully observed.
Engine power limited to 316 KW or 500 CV: not observed.
Mesh size in the cod-end (40 mm stretched): fully observed.
Fishing forbidden upper 50 m depth: not fully observed.
Time at sea (12 hours per day and 5 days per week): fully observed.

5.17.2.3. Catches

5.17.2.3.1. Landings

During the last decade, the annual landings of red mullet in GSA 5 have oscillated between 28 and 11 tons. After a marked decrease from 2000 (27.8 tons) to 2003 (10.5 tons) and a subsequent increase in 2004 (20.3 tons), landings have remained at low levels since then (11-18 tons).

Fig. 5.17.2.1.3.1 Landings (in tons) between 2000 and 2009.

Tab. 5.17.2.1.3.1 Landings (t) as submitted to the official DCF data call in 2010, 2002-2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	5	ESP	OTB	DEMSP	40D50	14	11	20	13	11	14	18	12

5.17.2.3.2. Discards

The discards of red mullet from trawlers are negligible (Carbonell *et al.*, 1997).

5.17.2.3.3. Fishing effort

Although there was a progressive diminution in the number of trawlers during the period 2000-2008, the total fishing effort remained rather constant because of the increase in vessel mean power (Fig. 5.17.2.3.3.1).

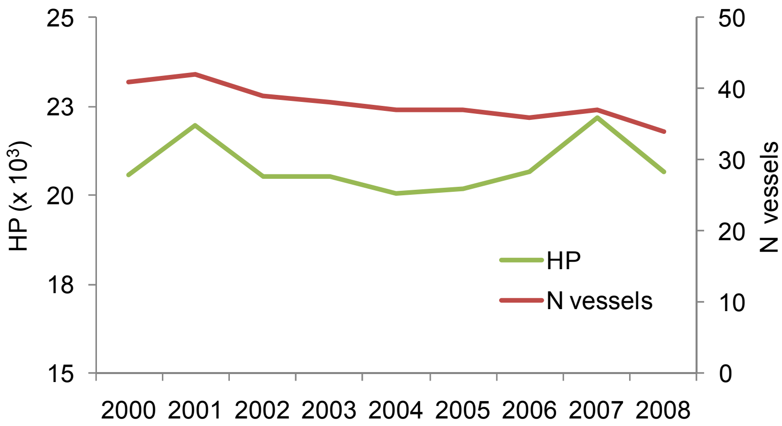


Fig. 5.17.2.3.3.1 Number of trawlers and total HP (mean HP x N of vessels) in Mallorca during 2000-2008.

No effort data were submitted to SGMED-10-02 by Spain.

5.17.3. Scientific surveys

5.17.3.1. MEDITS

5.17.3.1.1. Methods

The MEDITS data series in GSA 5 is rather short (since 2007) and will be evaluated when the 2010 data will be made available.

5.17.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.17.3.1.3. Trends in abundance and biomass

No analyses were conducted during SGMED-10-02.

5.17.3.1.4. Trends in abundance by length or age

No analyses were conducted during SGMED-10-02.

5.17.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.17.3.1.6. *Trends in maturity*

No analyses were conducted during SGMED-10-02.

5.17.4. Assessment of historic stock parameters

Red mullet was assessed in the STECF-SGMED-08-03 meeting, although by a mistake this assessment was not included in the final report. The assessment was subsequently presented to the GFCM hold in Izmir (Turkey) in 2008. In that case, the analyses performed were an XSA and a Y/R using the time series from 2000 to 2007. The recommendations to GFCM were to not increase the actual fishing effort since the resource was considered fully exploited, with the current Y/R close to the maximum and the current stock biomass being a 25% of the virgin stock.

5.17.4.1. Method 1: XSA

5.17.4.1.1. *Justification*

The length of the data series available (10 years, from 2000 to 2009) allowed the use of a VPA tuned with data from surveys (XSA). The software used was the Lowestoft suite (Darby & Flatman 1994). A separable VPA (Pope & Sheperd 1982) was also used as exploratory analysis.

5.17.4.1.2. *Input parameters*

Landings time series from 2000 to 2009 (Tab. 5.17.2.1.3.1). Length frequency distributions from on board monthly samplings developed during the entire time series (Fig. 5.17.4.1.2.1). Catch at age distributions are illustrated in Fig. 5.17.4.1.2.2.

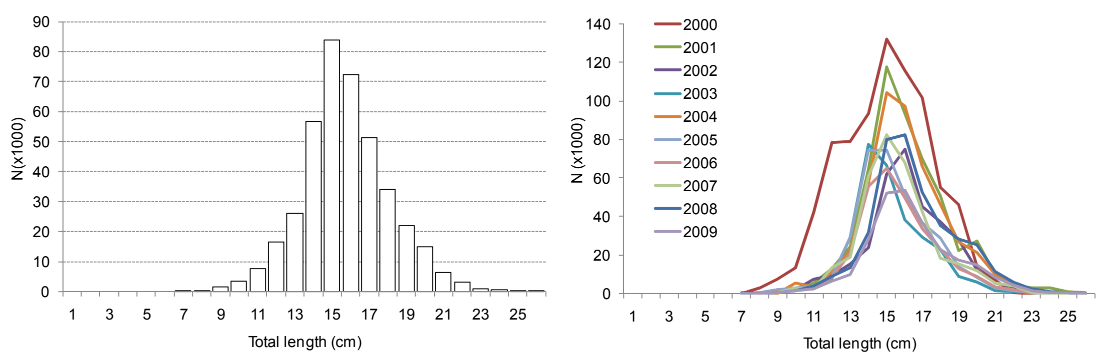


Fig. 5.17.4.1.2.1 Mean size frequency distribution (left) and distributions by year (right).

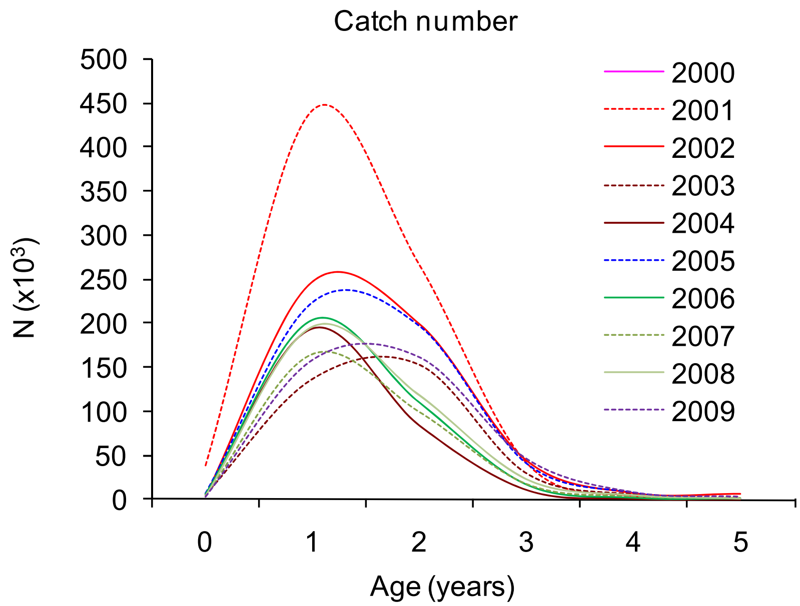


Fig. 5.17.4.1.2.2 Landings at age composition by year, 2000-2009.

Tab. 5.17.4.1.2.1 Landings at age composition by year, 2000-2009.

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	38	5	5	6	7	6	4	4	4	3
1	442	248	136	194	224	204	165	196	159	113
2	266	200	152	84	197	110	99	118	162	108
3	41	45	29	11	41	17	17	23	47	29
4	3	8	5	1	8	2	3	5	9	7
5	0	7	1	0	1	1	1	1	4	2
Total	789	513	328	296	477	340	290	348	385	262

The biological parameters used for the assessment were the following: 1) growth parameters agreed in the SGMED 09-01 meeting (L_{inf}= 26.0, K= 0.41, t_0= −0.40); 2) length-weight relationships obtained from the Spanish National Data Collection (a= 0.0062, b= 3.1597); 3) natural mortality at age (Tab. 5.17.4.1.2.2) calculated using the PROBIOM spreadsheet (Abella et al. 1997); and 4) maturity at age (Tab. 5.17.4.1.2.3) obtained from the Spanish National Data Collection in GSA05.

Tab. 5.17.4.1.2.2 Natural mortality (M) at age.

Age	0	1	2	3	4	5	Mean
M	0.77	0.49	0.32	0.27	0.25	0.24	0.39

Tab. 5.17.4.1.2.3 Maturity at age.

Age	0	1	2	3	4	5
Proportion of matures	0.30	0.57	0.80	0.92	0.97	0.99

Tab. 5.17.4.1.2.4 MEDITS tuning series of CPUE at age as used in the XSA.

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0.0245	0.0032	0.0029	0.0013	0.00001	0.0475	0.0143	0.002	0.0421
1	0.8861	0.1675	0.2915	0.1113	0.0163	0.5259	0.6328	0.2297	0.1877
2	0.2724	0.1982	0.1473	0.1535	0.0346	0.1441	0.3013	0.2188	0.1975
3	0.0534	0.0387	0.0405	0.043	0.0187	0.0502	0.0847	0.0507	0.0347
4	0.0108	0.0034	0.0079	0.0062	0.0026	0.0146	0.0146	0.007	0.0058
5	0.00001	0.0022	0.0043	0.0011	0.00001	0.0012	0.0011	0.0006	0.002

5.17.4.1.3. Results

Terminal fishing mortality (Ft) was obtained from the catch curve, using the FLEDA package (Jardim & Azevedo 2004), and adjusted afterwards with a previous VPA followed by a Separable VPA. Different trials were done to obtain the best results from the Separable VPA changing both the reference age and the terminal selection value. The best fit was obtained with a reference age of 2 and a terminal selection value of 0.85. The figures below (Fig. 5.17.4.1.3.1) show the residuals and the selection at age (Sa) curve in this last trial. Except two points in the first year, the residuals were always smaller than 1 (most of them <0.5) and did not show any tendency throughout the years. Finally, the vector of F by age, including the Ft, obtained with this Separable VPA was used as input parameters (Tab. 5.17.4.1.3.1).

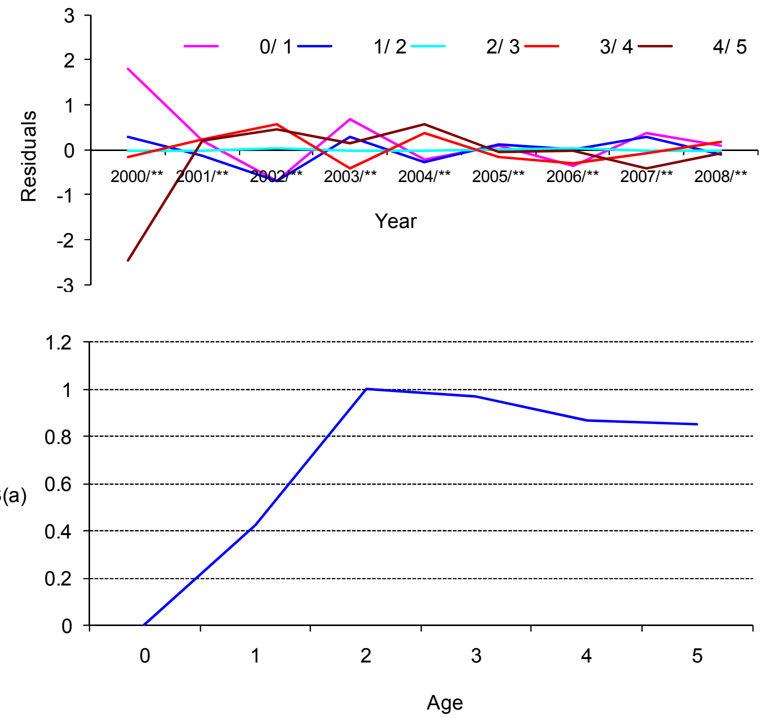


Fig. 5.17.4.1.3.1 Residuals and selection at age (Sa) curve from a Separable VPA.

Tab. 5.17.4.1.3.1 Fishing mortality (F) at age from a Separable VPA.

Age	0	1	2	3	4	5
F	0.006	0.561	1.321	1.281	1.144	1.123

The data used for tuning was the abundance (N/km^2) of *M. barbatus* obtained during the MEDITS surveys developed during 2001–2009 around the Balearic Islands. However, data from 2005 were rejected for tuning because in the first XSA trials they gave rather large residuals and poor fit (Fig. 5.17.4.1.3.2). Several subsequent XSA trials were also performed where the age at which catchability (q) is independent of stock size and the age at which q is independent of age were adjusted. The best result was obtained using q independent of stock size for all ages and q independent of age for ages >= 2. The vector of F by age, the q by age and the residuals by year and age obtained in this last trial are shown below (Fig. 5.17.4.1.3.3). The regression statistics from the XSA diagnostics (Tab. 5.17.4.1.3.2) showed rather bad fits in some ages, especially in ages 0 and 4, which indicate that abundance indices obtained in MEDITS are not very useful for this species and this area in particular.

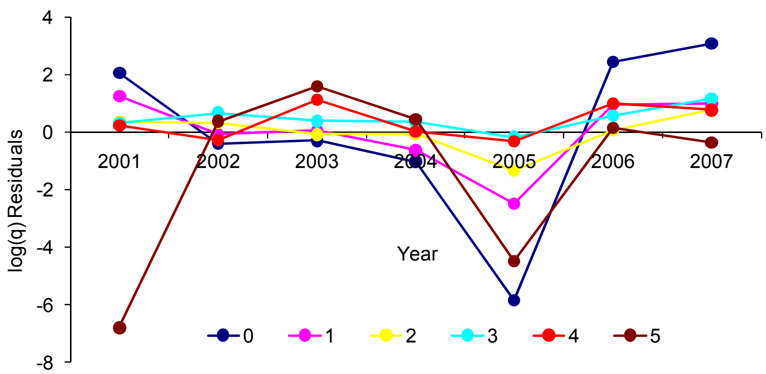


Fig. 5.17.4.1.3.2 Log (q) residuals obtained from a first XSA trial.

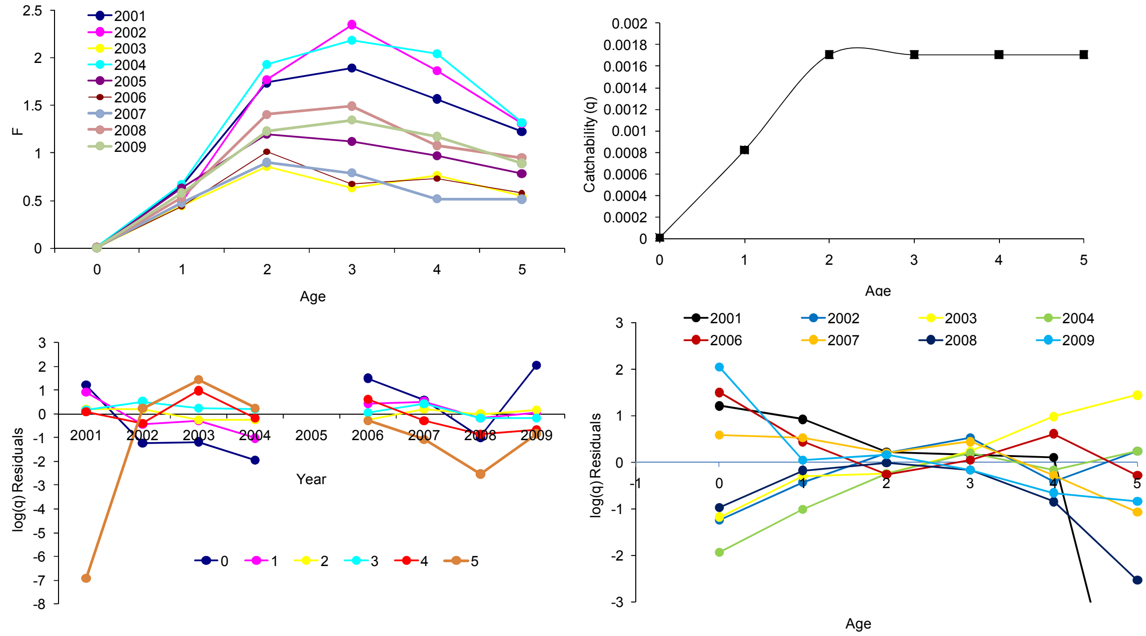


Fig. 5.17.4.1.3.3 Fishing mortality (F) and catchability (q) by age, along with the residuals by year and age obtained in the last XSA run.

Tab. 5.17.4.1.3.2 Regression statistics from the XSA diagnostics.

Age	Slope	t-value	Intercept	RSquare	N Points	Reg s.e	Mean Q
0	-1.57	-0.787	-0.08	0.02	8	2.43	-11.53
1	0.64	0.574	6.82	0.3	8	0.42	-7.1
2	0.77	0.715	6.14	0.61	8	0.17	-6.37
3	1.52	-1.095	7.46	0.42	8	0.38	-6.22
4	6.28	-3.295	28.92	0.06	8	2.52	-6.46
5	-0.71	-4.426	-3.9	0.53	8	0.96	-7.59

The Figures below (Fig. 5.17.4.1.3.4) show the main XSA results in terms of the fishing mortality by year and age, the stock biomass (SB) and spawning stock biomass (SSB) together with the relationship between both (SSB/SB), and the recruitment.

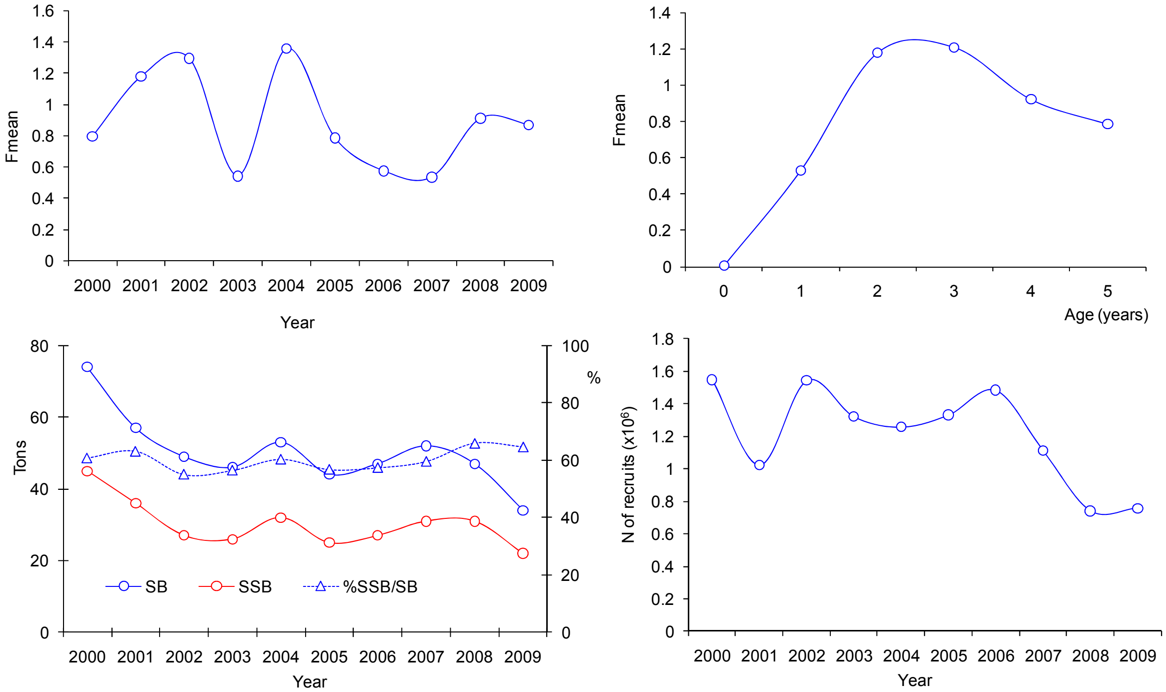


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Fig. 5.17.4.1.3.4 Main assessment results: mean fishing mortality (F_{mean}) by year and age (ages 1 to 4); stock biomass (SB), spawning stock biomass (SSB) and the percentage between both (%SSB/SB); and number of recruits at age 0 through 2000-2009.

Tab. 5.17.4.1.3.3 Estimated fishing mortality by year and age from the XSA, 2000-2009.

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0.0376	0.0066	0.0051	0.0065	0.0077	0.007	0.0039	0.0055	0.0075
1	0.7966	0.6467	0.4842	0.447	0.6697	0.629	0.4421	0.477	0.5309
2	1.5518	1.7357	1.7674	0.8557	1.9314	1.1954	1.014	0.9009	1.4055
3	1.3779	1.89	2.346	0.6361	2.182	1.1221	0.6729	0.7902	1.4916
4	0.1958	1.5656	1.8622	0.7615	2.0394	0.9713	0.7318	0.5182	1.0788
5	0.8	1.2211	1.3059	0.5429	1.3197	0.7839	0.5781	0.5145	0.9507

Tab. 5.17.4.1.3.4 Estimated stock size by year and age from the XSA, 2000-2010.

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	1547	1022	1545	1321	1257	1332	1484	1112	741	758	0
1	1033	669	456	691	590	560	594	664	497	330	339
2	392	282	213	171	268	183	181	232	250	177	112
3	63	61	37	27	54	29	41	49	70	45	39
4	17	12	7	3	11	4	7	16	16	12	9
5	0	10	2	1	1	1	1	2	7	4	3
Total	3051	2058	2260	2213	2180	2110	2309	2074	1581	1327	501

Tab. 5.17.4.1.3.5 Estimated stock summary table from the XSA, 2000-2009.

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 1-4
2000	1547	74	45	28	0.6183	0.9805
2001	1022	57	36	22	0.6277	1.4595
2002	1545	49	27	14	0.5358	1.6150
2003	1321	46	26	11	0.4041	0.6751
2004	1257	53	32	20	0.6333	1.7056
2005	1332	44	25	13	0.5157	0.9795
2006	1484	47	27	11	0.4227	0.7152
2007	1112	52	31	14	0.4379	0.6716
2008	741	47	31	18	0.585	1.1267
2009	758	34	22	12	0.5493	1.0805

5.17.5. Long term prediction

5.17.5.1. Justification

Yield per recruit analysis was conducted based on the exploitation pattern resulting from the XSA model and population parameters.

5.17.5.2. Input parameters

Minimum and maximum ages for the analysis were 0 and 5 years, respectively. Stock weight at age and catch weight at age were estimated as mean values on a long term basis (2000-2009). Natural mortality by age were from PROBIOM (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Fishing mortalities were estimated using the average over ages 1-4 of the last year (2009). Reference F was considered to be mean F for ages 1 to 4; Input parameters are shown in Tab. 5.17.5.2.1.

Tab. 5.17.5.2.1 Input parameters for the Y/R analysis.

Age group	Stock weight	Catch weight	Maturity	F	M
0	0.011	0.011	0.30	0.006	0.80
1	0.033	0.033	0.57	0.529	0.50
2	0.053	0.053	0.80	1.178	0.30
3	0.085	0.085	0.92	1.209	0.30
4	0.111	0.111	0.97	0.923	0.30
5	0.148	0.148	0.99	0.785	0.20

5.17.5.3. Results

Tab. 5.17.5.3.1 displays the reference fishing mortality (F_{ref}), along with the reference points $F_{0.1}$ and the F_{max}. Fig. 5.17.5.3.1 shows the results of the yield per recruit analysis showing the Y/R and SSB/R.

Tab. 5.17.5.3.1 Reference fishing mortality (F_{ref}) and the referent points $F_{0.1}$ and the F_{max}.

$F_{0.1}$	0.3133
F_{max}	0.8104
F_{ref}	1.0805

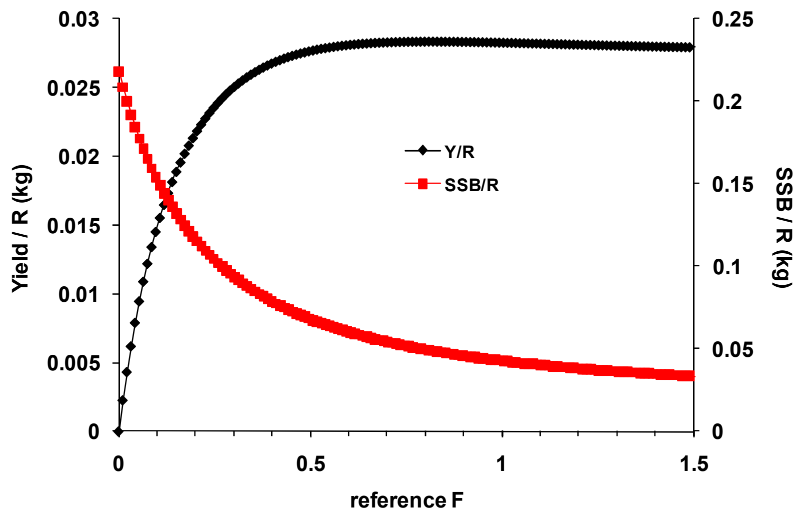


Fig. 5.17.5.3.1 Results of the yield per recruit analysis showing the Y/R and SSB/R.

5.17.6. Scientific advice

5.17.6.1. Short term considerations

5.17.6.1.1. State of the spawning stock size

Both SB and SSB showed a clear decrease from 2000 to 2003; SB decreased from 75 to 45 tons and SSB from 45 to 25 tons. Subsequently, both parameters remained rather constant or even increased slightly until 2007. However, SB showed a marked decreasing trend between 2007 and 2009, which was also followed by SSB; in both cases the lowest historical values were obtained in the last assessed year. In spite of this, SSB remained constant between 55 and 65% of the SB throughout the entire time series. As no management reference points are proposed, SGMED cannot fully evaluate the state of the SSB.

5.17.6.1.2. State of recruitment

With the exception of 2001, recruitment remained rather constant between 1.3 and $1.5 \cdot 10^6$ during 2002-2006. Since then, however, the number of recruits has decreased progressively to the point that the lowest historical values were reached during 2008-2009.

5.17.6.1.3. State of exploitation

Fishing mortality has ranged between 0.7 and 1.7 during the entire series and it is noticeable the abrupt decrease in 2003 coinciding with the lowest historical landings. Although fishing mortality has decreased progressively from 2004 to 2007, it has increased during the last two years. The vector of fishing mortality by age depictures a typical selection curve and shows that individuals between 2 and 3 years old suffer the highest fishing exploitation and also that there is no exploitation of the recruits (age 0). The current F_{ref} (1.0805) is above the Y/R $F_{0.1}$ reference point (0.3133), which indicates that red mullet in GSA 5 is subject to overfishing.

5.18. Stock assessment of red mullet in GSA 06

5.18.1. Stock identification and biological features

5.18.1.1. Stock Identification

Due to the lack of information about the structure of red mullet (*Mullus barbatus*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 06 boundaries.

5.18.1.2. Growth

SGMED-10-02 notes that no growth parameters were provided by DCF for red mullet in GSA 06. Taking into account the longest individuals measured in GSA 06, the set of parameters given for red mullet in GSA 09 were selected (L_{inf}= 29.0; k = 0.6, t_0= -0.1). These values are consistent with SGMED 09-01 recommendations, where it was agreed that a L_{inf} between 27 and 31 cm TL should be used for the estimation of M. The length-weight relationship parameters are a=0.0053 and b=3.12 (GSA 09).

5.18.1.3. Maturity

The maturity ogive was taken from DCF submitted data for the year 2002 in GSA 09, with size at first maturity (50 %) at around 13 cm TL.

Tab. 5.18.1.3.1 Maturity ogive adopted from GSA 09.

Age class	0	1	2	3	4
Maturity ratio	0	1	1	1	1

5.18.2. Fisheries

5.18.2.1. General description of fisheries

No updated information on the fishing fleet was submitted to SGMED-10-02. Trawl red mullet landings in GSA 06 in 2009 were 743 tons (compared to 12 tons in GSA 05 and 154 tons in GSA 01). According to studies conducted in particular ports of the GSA 06, trawl accounts for the majority (around 90% according to Martin *et al.,* 1999) of landings of red mullet, both in numbers and in weight. The exploitation of red mullet small individuals (recruitment fishery) occurs since decades (stated already by Demestre *et al.,* 1997). Spawning takes place in late spring and recruitment to the fishery occurs in early autumn, when juveniles are heavily exploited by trawlers (Sánchez *et al*., 1995; Martín *et al*., 1999; Lloret and Lleonart, 2002).

In its consolidated stock review in 2009 STECF concluded that red mullet in GSA 06 (Northern Spain) is exploited by trawl and artisanal fisheries, although small gears (trammel nets and gillnets) account only for 5% of the total landings of these species. Landings of *M. barbatus* increased continuously from the earliest 1970's until 1998. From this year until 2006 a general decreasing trend with some fluctuations is observed. In the period 1998-2004 landings of this species averaged 1,315 t per year. Estimated landings for the year 2007 are the highest in the data series. An important fraction (30% of individuals) of *M. barbatus* is under the minimum legal size. The trawl fleet operating in this area is composed by 647 boats averaging 47 TRB, 58 GT and 297 HP. Trawl fisheries developed along the continental shelf and upper slope are multi-specific. Small vessels operate almost exclusively on the continental shelf targeting on red mullets, octopus, cuttlefish and sea breams. Medium and large vessels usually operates on the slope areas, but some of these units can also operate on the continental shelf (e.g. red mullet is more intensively exploited from September to November).

5.18.2.2. Management regulations applicable in 2009 and 2010

The Spanish Adminsistration acknowledged the poor status of certain demersal species in the Spanish Mediterranean waters and approved a regulation for the conservation of the fishing resources (*ORDEN APA/254/2008, de 31 de enero, por la que se establece un Plan integral de gestión para la conservación de los recursos pesqueros en el Mediterráneo*). This regulation, in line with EU regulations, includes the implementation of spatial and temporal closures along the Spanish coast, and limits the daily and weekly fishing effort to 12 hours per day five days a week.

Minimum landing sizes: Spanish Real Decreto 560/1995 and EC regulation 1967/2006 defined 11 cm TL as minimum legal landed size for red mullet.

On the 31 of May of 2010, the derogation to the minimum mesh size of towed nets stated at the article 14.1 of the EC COUNCIL REGULATION (EC) No 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Therefore, since 1st June 2010 the towed net used must be a square-meshed net of 40 mm at the cod-end or a diamond meshed net of 50 mm.

5.18.2.3. Catches

5.18.2.3.1. Landings

Fig. 5.18.2.3.1.1 and table 5.18.2.3.1.1 show the annual reported red mullet landings taken by trawlers. The data were reported to SGMED-10-02 through the Data Collection Framework. The annual landings 2002-2009 oscillated between ca 700 and 1,400 tons. The 2009 annual landings is the lowest recorded (743 t). From 2002 to 2005 (Fig. 5.18.2.3.1.2), landings were dominated by individuals of age 0 (mostly juveniles) whereas from 2006 till present (2009) landings have been dominated by ages 1+ (adults).

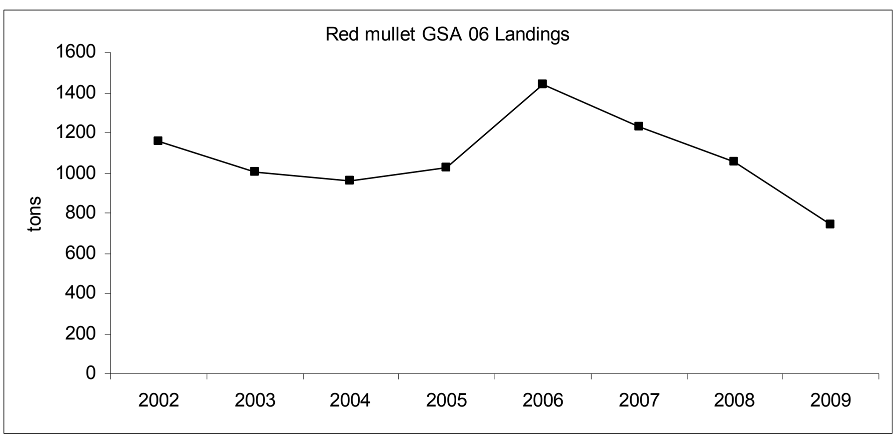


Fig. 5.18.2.3.1.1 Annual red mullet landings (t) by trawlers.

Tab. 5.18.2.3.1.1 Annual landings (t) by fishing technique (otter trawlers only) in GSA 06.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	6	ESP	OTB	DEMSP	40D50	1159	1004	958	1027	1437	1232	1056	743

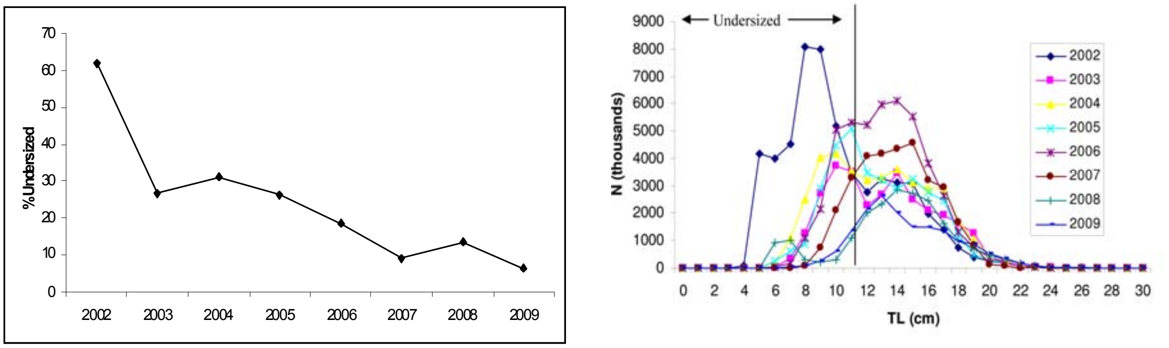


Figure 5.18.2.3.1.2. Landings in numbers of red mullet in GSA 06 during the period 2002-2009 (on the right) and the proportion of undersized individuals (on the left). Minimum legal size of red mullet = 11 cm TL.

5.18.2.3.2. Discards

Reported discards through the DCR data call to SGMED-10-02 amount to 9.3 t in 2005 and 1.5 t in 2009. Since the sizes of discarded individuals are unknown, fishing mortality of small juveniles is not estimated. However, in a study conducted by Sánchez *et al.* (2007), *Mullus barbatus* showed very low discard rates in the Catalan Sea (northern part of GSA 06).

5.18.2.3.3. Fishing effort

The fishing effort data for GSA 06 was not submitted by the Spanish authorities to SGMED-10-02. STECF (stock review part II in 2009) noted that the trawl fishery off northern Spain (GSA 06) is carried out by around 647 vessels.

5.18.3. Scientific surveys

5.18.3.1. Medits

5.18.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were calculated. In GSA 06 the following number of hauls was reported per depth stratum (see Table 5.18.3.1.1.1).

Tab. 5.18.3.1.1.1. Number of hauls per year and depth stratum in GSA 06, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA06 10-50	7	8	7	8	7	8	9	8	11	9	9	11	12	6	8	6
GSA06 50-100	21	28	27	26	28	30	30	31	36	39	31	32	34	40	43	28
GSA06 100-200	11	19	17	15	13	17	19	20	20	21	17	18	19	24	30	20
GSA06 200-500	10	13	10	12	7	13	12	16	17	18	16	15	18	18	19	12
GSA06 500-800	7	8	9	7	4	9	6	8	7	11	11	8	10	15	14	9

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

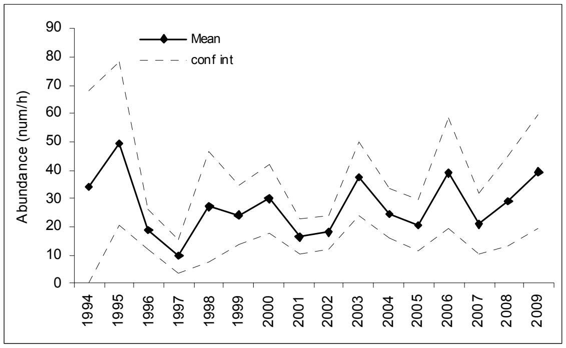
Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.18.3.1.2. Geographical distribution patterns

No specific analyses were conducted. However, Lombarte *et al*. (2000) studied the spatial distribution of red mullet in GSA 06 and showed that this species shows a clear preference (higher densities) for muddy areas where the shelf becomes wider.

5.18.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 06 was derived from the international survey MEDITS. Figure 5.18.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 06. The hauls indicate a general increasing trend in both abundance and biomass since 1997 till present (2009). This increasing trend does not fit with the negative trend observed in landings (see figure 5.18.2.3.1.1 above). The difference is probably due to the fact that MEDITS surveys, conducted in spring, do not cover the recruitment peak (early autumn; Sánchez *et al*., 1995).



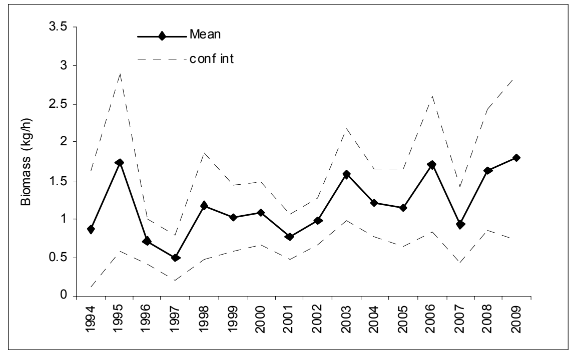


Fig. 5.18.3.1.3.1 Abundance and biomass indices of red mullet in GSA 06.

5.18.3.1.4. Trends in abundance by length or age

The following Fig. 5.18.3.1.4.1 and 2 display the stratified abundance indices of GSA 06 in 1994-2001 and 2002-2009. These size compositions are considered preliminary.

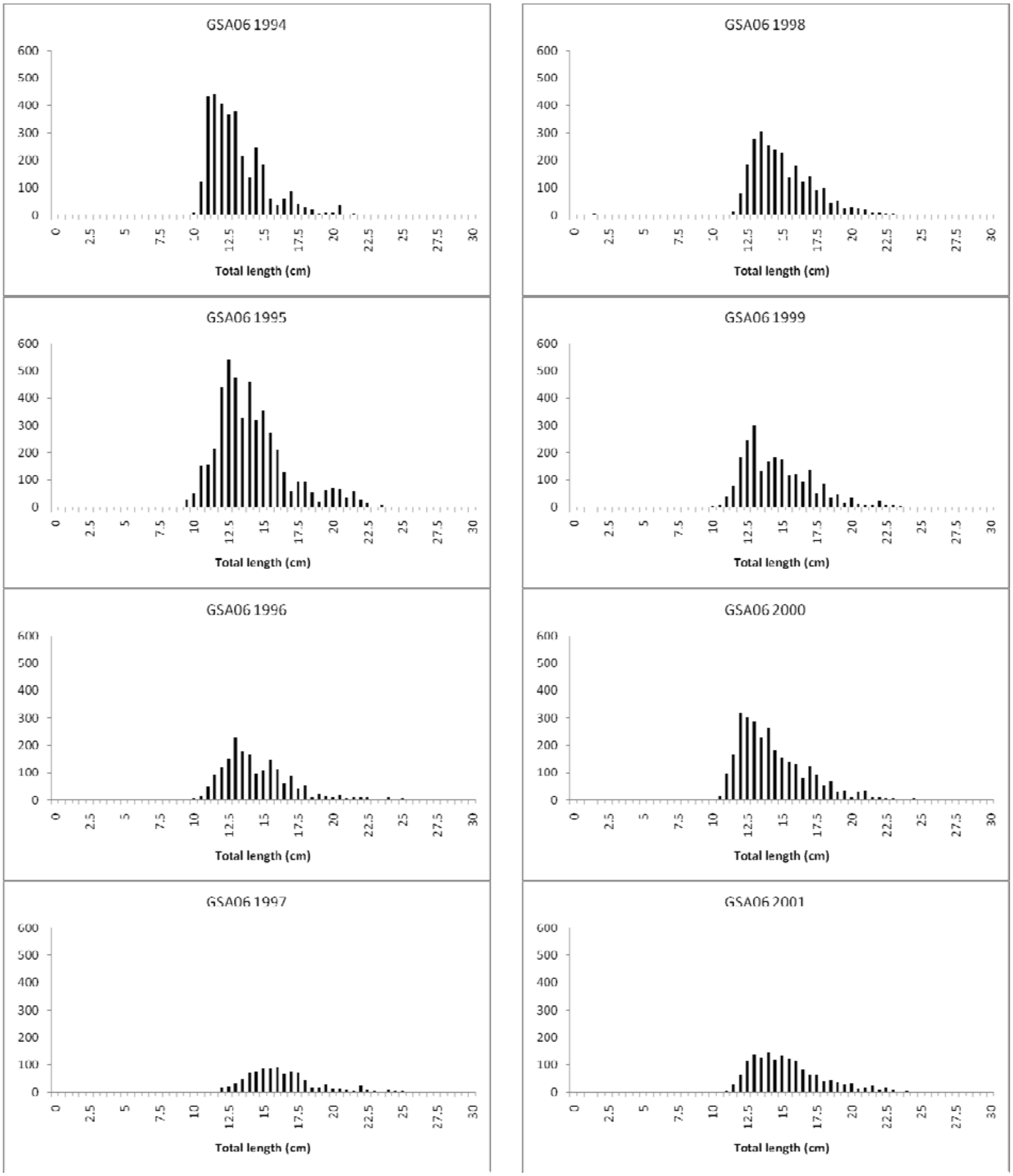


Fig. 5.18.3.1.4.1 Stratified abundance indices by size, 1994-2001.

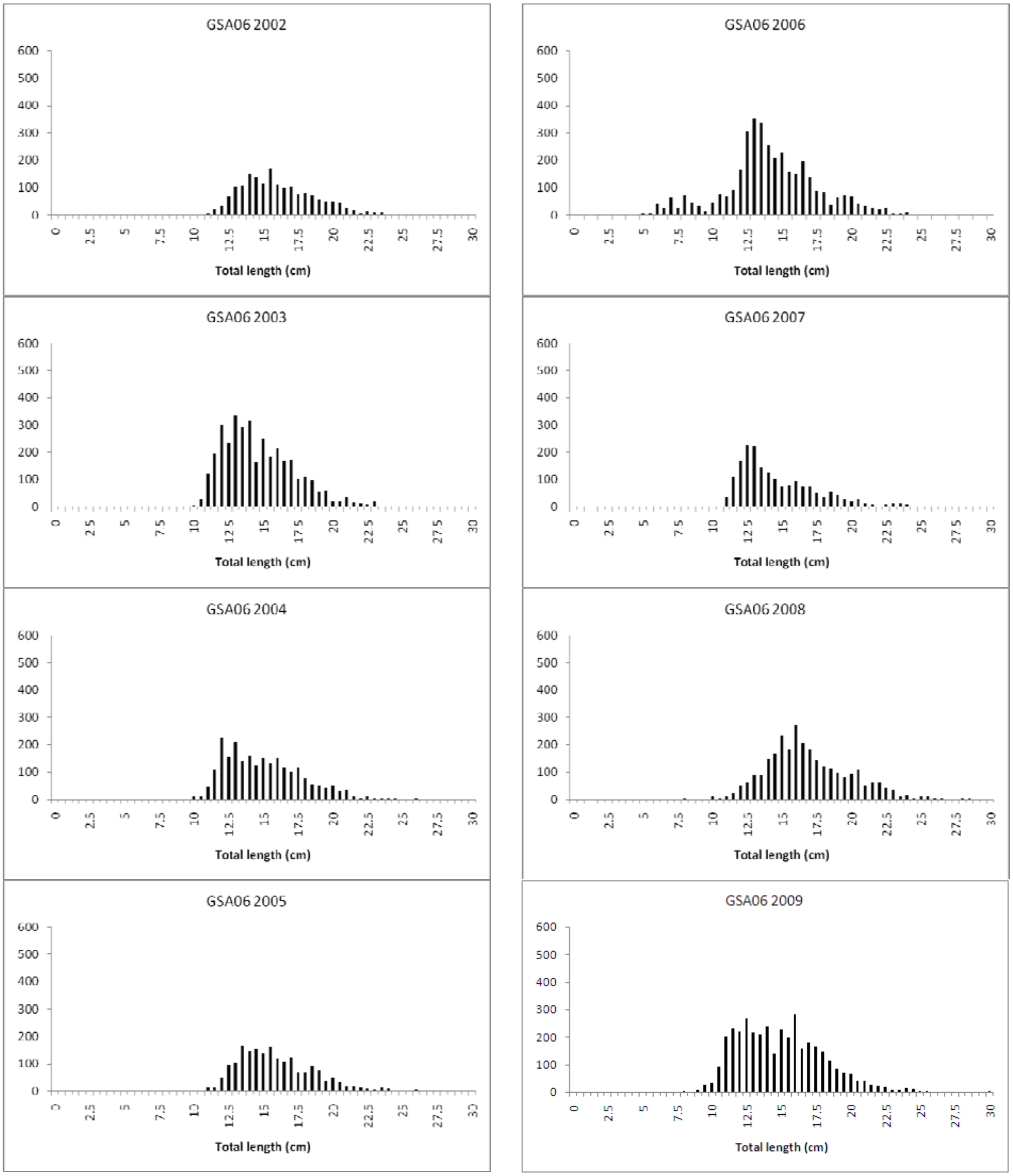


Fig. 5.18.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.18.3.1.1. Trends in growth

No analyses were conducted during SGMED-10-02.

5.18.3.1.2. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.18.4. *Assessment of historic stock parameters*

5.18.4.1.1. Method 1: XSA

5.18.4.1.2. Justification

An XSA was performed calibrated with fishery independent survey abundance indices (MEDITS).

5.18.4.1.3. Input parameters

Input data were taken from DCR. Numbers at age for 2009 were missing, thus the annual length distributions of the landings in 2009 were transformed to ages using L2Age4.exe (estimated using the numbers by size and the growth parameters).

Since there is no data on effort, a virtual value of 1 was used in all years.

We used the growth curve given for red mullet in GSA 09, which fits to our size data distribution and are consistent with SGMED 09-01 recommendations. The growth parameters are: L_{inf}= 29, K=0.6, $t_{0=}$ -0.1. Minimum and maximum age for the analysis was considered to be age group 0 and 10, respectively

Table 5.18.4.1.3.1 lists the input parameters to the XSA, i.e. catch at age, weight at age, maturity at age, natural mortality at age and the tuning series at age (MEDITS). Natural mortality values (vector) were computed with PROBIOM. M of age group 0 is the mean over the first 12 months. M values used in the present assessment are higher than the ones used in the previous one conducted by SCSA/SAC/GFCM in 2008 (and reviewed by SGMED 08-04), reflecting the different growth parameters used in these two assessments. The high values of M used in the present assessment fit with the expected impact of the high trawling efforts on the physiological condition of red mullet in GSA 06 (Lloret *et al*., 2007) because condition may impinge on natural mortality as reviewed during SGMED 09-01. The high M values used in this assessment also agree with those computed in the Izmir Bay (Aegean Sea), an area closed to commercial trawling and beach seining, by Ozbilgin et al. (2004) using length frequency analysis (overall M=1.07).

The assessment conducted by GFCM in 2008 can be viewed at http://www.gfcm.org/gfcm/topic/17101/en, click on "SCSA Working Group on Demersal Species, including joint Stocks Assessments (September 2008)", open folder "stock assessment forms" and open document "GFCM_SCSA_2008_gsa06_MUT.xls".

The tuning parameters (MEDITS) were calculated by transforming the MEDITS length distributions to ages using L2Age4.exe. Tuning is however limited by the fact that MEDITS and landings are poorly correlated.

It should be also considered that the assessment conducted by SGMED (this report) is based on a short time series of data (2002-2009) and therefore results should be taken with caution.

Table 5.18.4.1.3.1 The input parameters to the XSA, i.e. catch at age, weight at age, maturity at age, natural mortality at age and the tuning series at age (MEDITS).

Red mullet GSA06 Catch at age.

Age	2002	2003	2004	2005	2006	2007	2008	2009
0	49451.1	22426.4	28610.2	18966.9	21469.5	11979.9	6089.8	7230.8
1	4464.4	6284.7	8117.9	10270	18236.4	13938.9	11940.5	8563.7
2	662.3	1342.9	1351.4	4486.2	5055.6	5673	4578.7	752.1
3	156.2	139.4	235.8	688.9	881.4	663.7	1348.2	32
4+	59.4	69.9	57	271.2	231.1	99.8	657.177	12.8

Red mullet GSA06 Weight at age in kg.

Age	2002	2003	2004	2005	2006	2007	2008	2009
0	0.011	0.018	0.017	0.015	0.017	0.019	0.016	0.017
1	0.051	0.054	0.053	0.038	0.037	0.038	0.037	0.037
2	0.086	0.082	0.084	0.063	0.062	0.063	0.065	0.063
3	0.121	0.119	0.120	0.093	0.091	0.087	0.095	0.091
4+	0.102	0.103	0.171	0.186	0.184	0.184	0.187	0.185

Males and females combined

Age group	Maturity ratio	M
0	0	1.36
1	1	0.77
2	1	0.66
3	1	0.61
4	1	0.58
5	1	0.56
6	1	0.55
7	1	0.54
8	1	0.53
9	1	0.53
10	1	0.52

Tuning parameters (MEDITS)

MEDITS TUNING

AGE	2002	2003	2004	2005	2006	2007	2008	2009
0	157.0	948.3	604.5	193.7	1153.3	583.5	182.2	1125.0
1	1440.9	2467.1	1606.6	1566.3	2346.7	1187.5	2158.5	2418.0
2	153.5	130.0	139.8	145.3	203.0	106.0	417.7	198.0
3	10.4	7.8	16.0	7.5	16.0	13.2	40.6	26.0
4+	0.0	0.5	3.4	5.4	0.0	0.0	11.8	6.0

5.18.4.1.4. Results including sensitivity analyses

The following Table 5.18.4.1.4.1 lists the tuning settings and estimated fishing mortality at age as estimated by XSA.

Table 5.18.4.1.4.1 Tuning settings and fishing mortality 2002-2009 at age and stock numbers at age 2002-2010.

Regression weights

	2002	2003	2004	2005	2006	2007	2008	2009
	0.877	0.921	0.954	0.976	0.99	0.997	1	1

log catch residuals

Age	2002	2003	2004	2005	2006	2007	2008	2009
0	2.98	-2.53	-1.17	2.72	-3.17	-0.3	3.91	-2.29
1	2.48	-0.82	1.36	1.23	-1.76	2.08	-2.86	-1.39
2	0.72	-0.17	-0.66	-1.02	-0.56	-1.4	1.55	1.56
3	-0.5	-0.97	-1.03	-2.47	-1.72	-1.61	-0.28	2.14

F

Age	2002	2003	2004	2005	2006	2007	2008	2009	Fbar 2007-20(
0	0.765	0.285	0.330	0.168	0.274	0.260	0.135	0.170	0.188
1	0.597	0.551	0.424	0.523	0.712	0.898	1.951	0.894	1.248
2	0.713	0.698	0.391	0.908	1.177	1.081	3.789	1.500	2.123
3	0.726	0.533	0.408	0.615	0.796	0.811	2.062	0.843	1.239
4+	0.726	0.533	0.408	0.615	0.796	0.811	2.062	0.843	1.239
Fbar 1-3	0.679	0.594	0.408	0.682	0.895	0.930	2.601	1.079	

Stock numbers at age (thousands)

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	183000	179000	201000	242000	177000	103000	95000	91200	
1	14600	21800	34500	37100	52600	34600	20500	21300	19700
2	1810	3720	5810	10500	10200	11900	6520	1350	4030
3	411	458	955	2030	2180	1620	2100	76	155
4+	164	242	246	795	558	325	909	29	27
TOTAL	199985	205220	242511	292425	242538	151445	125029	113955	23912

The following Table 5.18.4.1.4.2 provides the summary of stock parameters as estimated by XSA.

Table 5.18.4.1.4.2 Summary of stock parameters as estimated by XSA.

	RECRUITS Age 0	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 1- 3
2002	182524	2971	964	1159	1.2026	0.679
2003	178730	4775	1558	1004	0.6444	0.594
2004	200834	5883	2469	958	0.388	0.407
2005	242378	6030	2394	1027	0.429	0.682
2006	177024	5881	2872	1437	0.5004	0.895
2007	103349	4212	2248	1232	0.548	0.930
2008	94973	3067	1547	1056	0.6823	2.600
2009	91184	2435	885	743	0.8399	1.079
Arith. Mean	158875	4407	1867	1077	0.6543	0.983
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

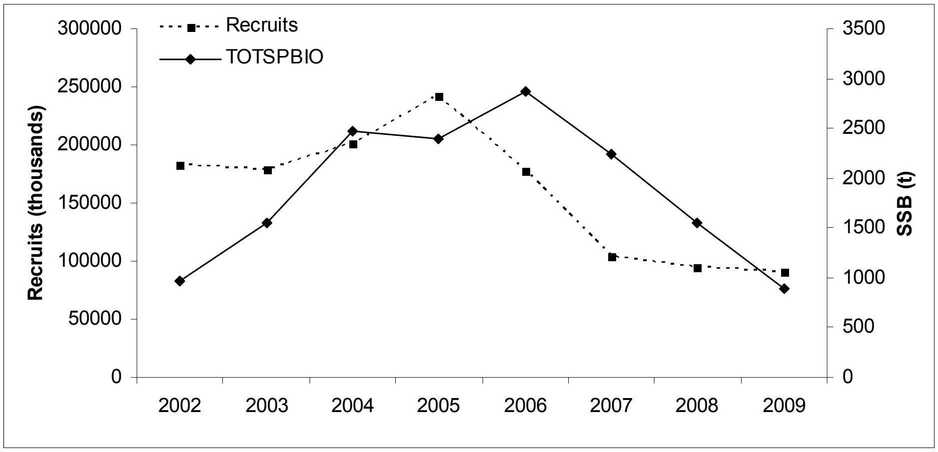


Fig. 5.18.4.1.4.1 Trends in spawning stock SSB and recruits (age 0).

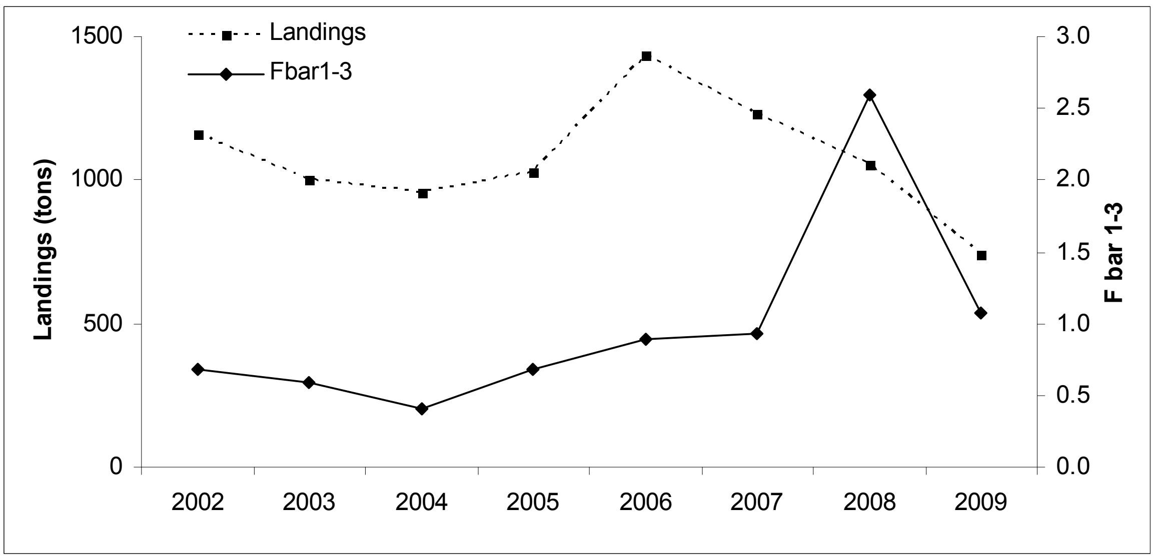


Fig. 5.18.4.1.4.2 Trends in landings and mean fishing mortality over ages 1-3.

Recruitment and SSB show a decreasing trend since 2005 and 2006 respectively. Recruits become mature within their first year of life, and this can explain the one-year lag difference between the declining trend of the recruits and the SSB.

Since class 0 is not fully recruited to the fishing gear, the mean F ages 1-3 is shown, being these ages the most affected by trawl, showing the highest F. Fishing mortality shows an increase since 2004. Particular high F values were observed in 2008, which seem rather unrealistic considering that the fishing fleet behaviour and size probably did not change significantly from year to year.

5.18.5. Long term prediction

5.18.5.1. Justification

A YpR analysis has been conducted.

5.18.5.2. Input parameters

Table 5.18.5.2.1 Input parameters of the YpR analysis.

age group	stock weight	catch weight	maturity	F	M
0	0.016	0.016	0	0.170	1.36
1	0.044	0.044	1	0.894	0.77
2	0.072	0.072	1	1.500	0.66
3	0.104	0.104	1	0.843	0.61
4	0.133	0.133	1	0.843	0.58
5	0.160	0.160	1	0.843	0.56
6	0.183	0.183	1	0.843	0.55
7	0.194	0.194	1	0.843	0.54
8	0.151	0.151	1	0.843	0.53
9	0.160	0.160	1	0.843	0.53
10	0.135	0.135	1	0.843	0.52

5.18.5.3. Results

$F_{0.1}$ amounts to 0.74. F_{ref} equals 1.08 and was computed as the mean F 1-3 in the most recent year (2009) (Figure 5.18.5.3.1). Y/R reference points were not considered precisely estimated due to the flat-topped shape of the yield curve and should be carefully interpreted as they are probably overestimated. However, SGMED recommends the $F_{0.1}$ to be used and propose F=0.74 as a management limit reference point until better data are available.

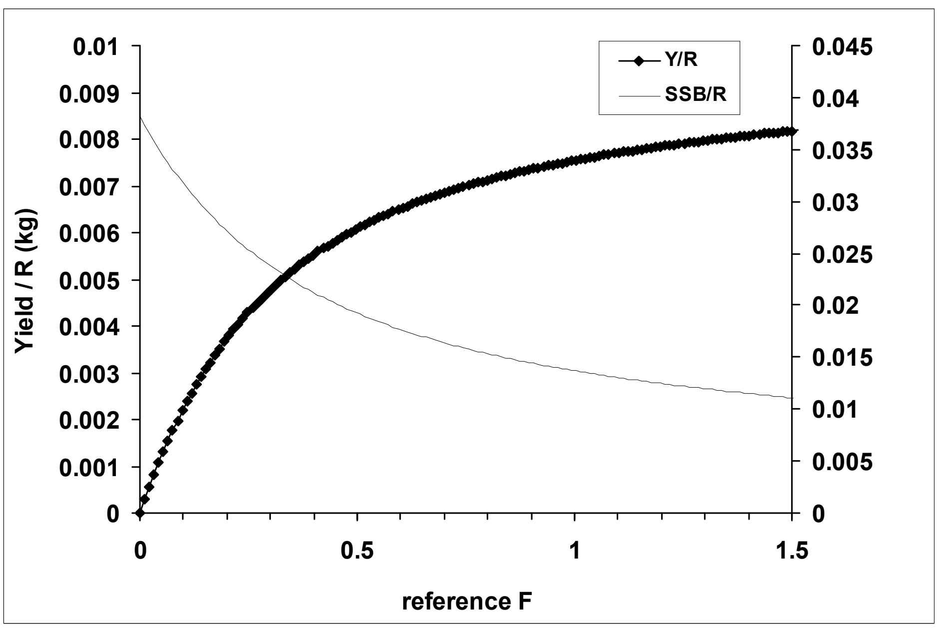


Fig. 5.18.5.3.1 Results of the YpR analysis.

5.18.6. Data quality and availability

From the DCF data files, effort data were not available as well as landings by age in 2009.

Values of certain files do not fit. When summing up the annual landings at age (tons) and compare it with the annual landings (tons), there are large differences in 2002 and 2003.

Since the sizes of red mullet discarded are unknown, we don't know exactly the fishing mortality of small juveniles, which are heavily fished during autumn (Sánchez et al., 1995; Martín et al., 1999).

Even though trawl is the responsible of the major part of the landings (around 80-90% according to Martín *et al.*, 1999), the landings attributed to other gears, basically trammel nets, should be reported and included in the assessment.

5.18.7. *Scientific advice*

5.18.7.1. Short term considerations

5.18.7.1.1. *State of the spawning stock size*

The SSB in 2009 represents the lowest value of the time series and a short term recovery seems unlikely if we consider that recruitment is also at a low level in 2009. However, it must be taken into account that age 0 groups are juveniles while 1 year old individuals are already mature; the stock is highly sensitive to recruitment and SSB changes in the short term. However, it must be noted that the MEDITS data (which mainly concentrates on the spawning fraction of the population) does not show this pessimistic figure. SGMED considered that this assessment is based on a short time series of data and not suitable to suggest reference points for biomass or spawning stock biomass.

5.18.7.1.2. *State of recruitment*

The recruitment in 2009 attained the lowest value of the time series after a continued decrease since 2007.

5.18.7.1.3. *State of exploitation*

Although imprecisely estimated, SGMED proposed $F_{0.1}$=0.74 for ages 1-3 to be used as a management limit of exploitation. With the F_{ref} being estimated at 1.08, SGMED concludes the stock being subject to overfishing. Thus, SGMED recommends a reduction in fishing effort of the trawl fleet, particularly during the spawning season (late spring) and/or the recruitment season (early autumn) in the context of a multi-annual management plan taking into account the multi-species landings of the trawl. SGMED is unable to precisely quantify the effort reduction required.

The results from this assessment are in line with the assessment of red mullet in GSA 06 conducted by SCSA/SAC/GFCM in 2008 and reviewed by SGMED 08-04. Both assessments show similar results regarding the overexploitation status of the red mullet stock in GSA 06, albeit our results show lower values of F than those from the previous assessment. The different input data set used in both assessments (number of years, tuning fleets, growth parameters and M values) explain these differences. It is worth noticing that analyses conducted more than ten years ago already highlighted the situation of overexploitation of red mullet in the Spanish Mediterranean shelf (*Martín et al*., 1999; Demestre *et al*., 1997). In the same sense, the review made by Oliver (2000) indicated that from 32 assessments of red mullet conducted in the Mediterranean till 2000 (conducted mostly with VPA or LCA together with a Y/R analysis), in 56% of the cases results showed a state of overfishing while in the 44% left showed a state of fully fished.

The only positive aspect in GSA 06 is that albeit the enforcement of the minimum landing size regulation appeared poorly implemented in the beginning of the 2000s, it has much improved during the last few years (in 2009, only 6% of the specimens were undersized). This aspect should even ameliorate since 1st June 2010, when square-meshed nets of 40 mm at the cod-end or diamond meshed nets of 50 mm will be used. Previous studies already analyzed the positive impact on the stock of a change in the configuration from diamond- to square-mesh on size selectivity of red mullet as well as on other demersal species in the Mediterranean (see e.g. Sala et al., 2008; Bahamon et al., 2006). SGMED 08-04 already noted (transition analysis) that an increase in Y/R between 20 and 30% were expected with a change to the square mesh in the cod-end. Therefore the enforcement of this change in the gear selectivity should have a short term negative impact on landings (under the status quo fishing effort) but should benefit the stock productivity in the near future.

5.19. Stock assessment of red mullet in GSA 07

5.19.1. Stock identification and biological features

5.19.1.1. Stock Identification

In GSA 07, red mullet is distributed along the shelf from the coast until 200 m depth. Whereas adults are most abundant at 100-150 m depth, juveniles (groups 0-1) are close to the coast during autumn and winter.

5.19.1.2. Growth

The growth and length-weight parameters used in the analyses of *M. barbatus* (GSA 07) are those identified during SGMED 08-03 for GSA 07:

Linf=26, K=0.41, t_0=-0.4.
L/W relationship: a=0.0081; b=3.113.

5.19.1.3. Maturity

Red mullet spawning period in GSA 07 extends from May to August with a peak in June-July. The length at first maturity is 12 cm (Spanish National Data Collection in GSA 5).

5.19.2. Fisheries

5.19.2.1. General description of fisheries

In the Gulf of Lions (GFCM-GSA 07), red mullet (*Mullus barbatus*) is exploited by both French and Spanish trawlers. Around 120 boats are involved in this fishery. According to official statistics, total annual landings for the period 2004-2009 have oscillated around a mean value of 193 tons. Most boats and catches correspond to the French trawling fleet (77% and 86% respectively). In French and Spanish landings, modal lengths are 13 and 14 cm, respectively.

In GSA 07, the trawl fishery is a multi-specific fishery. In addition to *M. barbatus*, the following species can be considered important by-catches: *Merluccius merluccius, Lophius sp., Pagellus sp., Trachurus sp., Mullus surmuletus, Octopus vulgaris, Eledone sp., Scyliorhinus canicula, Trachinus sp., Triglidae, Scorpaena sp*.

Length at first capture is about 7 cm. Catch is mainly composed by individuals of age 0 and 1, while the oldest age class (5+ group) is poorly represented. Catch rates decreased a little along the analyzed period. The number of French boats decreased also about 30 % during that period.

5.19.2.2. Management regulations applicable in 2009 and 2010

French trawlers:

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 CV: not observed
- Cod-end mesh size (bottom trawl: square 40 mm; pelagic trawl: diamond 20 mm): not fully observed
- Fishing forbidden within 3 miles (France): not fully observed
- Time at sea: fully observed

Spanish trawlers:

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 CV: not observed
- Mesh size in the codend (40 mm diamond): fully observed
- Fishing forbidden at <50 m depth: fully observed
- Time at sea: fully observed

5.19.2.3. Catches

5.19.2.3.1. Landings

Tab. 5.19.2.3.1.1 Annual landings (in tons) of otter trawlers in GSA 07 for the French (FRA) and Spanish (ESP) fleets.

COUNTRY	2002	2003	2004	2005	2006	2007	2008	2009
FRA	163	204	151	148	183	172	111	120
ESP	16	17	26	28	33	37	21	26

5.19.2.3.2. Discards

Reported discards through the DCF data call to SGMED-10-02 appear unreasonable high for the years 2005 and 2006. These data should be revised since it is known that this species is not discarded in the GSA 07. No discards were observed in 2009.

5.19.2.3.3. Fishing effort

Tab. 5.19.2.3.3.1 shows the fishing effort by fishing technique deployed in GSA 07 during 2003-2008. The data were reported to SGMED-10-02 trough the DCR data call. No values were reported for 2002. Spanish data were not available from the data call. Considering the French trawlers, the number of boats has decrease about 30 % throughout the period assessed.

Tab. 5.19.2.3.3.1 Trends in fishing effort by fishing technique deployed in GSA 07, 2003 to 2008. No values were reported for 2002.

TYPE	AREA	COUNTRY	FT_LVL4	2003	2004	2005	2006	2007	2008
DAYS	7	FRA	DRB	14016	11879	20632	15862	11466	8913
DAYS	7	FRA	FPO	4832	3704	3752	9712	7104	3659
DAYS	7	FRA	FYK	18087	24240	15856	16393	13986	11688
DAYS	7	FRA	GNF	40179	44379	58398	55776	54866	49161
DAYS	7	FRA	GNS	5278	5868	4973	2153	3238	1501
DAYS	7	FRA	GTR	36410	42371	49978	71342	56444	46983
DAYS	7	FRA	LA.	3308		1124	749	602	574
DAYS	7	FRA	LLS	15301	10685	11442	12808	8291	9775
DAYS	7	FRA	MIS	15926	14201	14804	35570	21477	19865
DAYS	7	FRA	OTB	42473	28242	21039	21297	20778	18430
DAYS	7	FRA	OTM	11919	4212	5901	6940	3622	2948
DAYS	7	FRA	SB-	2119	1778	1495	2831	1659	1667
GT*days	7	FRA	DRB	16086	13931	86216	46530	36716	18754
GT*days	7	FRA	FPO	15277	12063	13412	44521	31018	13791
GT*days	7	FRA	FYK	13367	24410	17241	15110	14353	12151
GT*days	7	FRA	GNF	115866	154780	178958	157379	225428	212101
GT*days	7	FRA	GNS	87300	82051	74160	18252	27824	8399
GT*days	7	FRA	GTR	146240	150874	176039	251669	251974	192206
GT*days	7	FRA	LA.	66549		15500	27016	21527	16910
GT*days	7	FRA	LLS	41399	30095	32006	38437	32262	29565
GT*days	7	FRA	MIS	28691	28733	30249	47655	30124	29249
GT*days	7	FRA	OTB	3055410	2009196	1461372	1782382	1604529	1412831
GT*days	7	FRA	OTM	1338274	500034	736179	937389	444863	352366
GT*days	7	FRA	SB-	9489	6507	4889	21627	32568	47803
kW*days	7	FRA	DRB	701658	498937	1446390	1474302	838511	503036
kW*days	7	FRA	FPO	543235	362280	332514	1039964	803688	384117
kW*days	7	FRA	FYK	439690	918434	633578	383108	438750	358399
kW*days	7	FRA	GNF	2846442	3221150	4273917	4580080	4743557	4085999
kW*days	7	FRA	GNS	896281	869433	749969	307954	458826	116992
kW*days	7	FRA	GTR	2381824	2734374	3335217	5657420	4661238	3519840
kW*days	7	FRA	LA.	671916		131612	170907	144068	128347
kW*days	7	FRA	LLS	919296	662464	634850	1014367	795610	806093
kW*days	7	FRA	MIS	881266	754958	569204	1927473	1093578	1102514
kW*days	7	FRA	OTB	12970505	8450443	5870844	6219184	5938674	5277458
kW*days	7	FRA	OTM	3766550	1330992	1864890	2193060	1144433	931468
kW*days	7	FRA	SB-	272065	145083	60475	364747	291432	304153

5.19.3. Scientific surveys

5.19.3.1. Medits

5.19.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 07 the following number of hauls was reported per depth stratum (s. Tab. 5.19.3.1.1.1).

Tab. 5.19.3.1.1.1. Number of hauls per year and depth stratum in GSA 07, 1994-2009.

STRATUM (m)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
10-50	12	12	12	15	12	12	12	12	12	13	12	12	12	15	12	11
50-100	32	32	32	38	39	33	33	33	32	38	31	31	33	31	25	30
100-200	10	9	9	9	9	9	10	9	9	10	13	11	10	10	7	10
200-500	6	6	5	6	5	5	6	6	5	5	5	5	5	5	4	5
500-800	8	7	5	5	4	5	6	5	4	5	6	5	6	5	5	6

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai) / A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = $Yst \pm t(\text{student distribution}) * V(Yst) / n$

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.19.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.19.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 07 was derived from the international survey Medits. Figure 5.19.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 07.

The estimated abundance and biomass indices do not reveal any significant trends since 1994. However, the recent abundance and biomass indices in 2007 appear high but are subject to high uncertainty.

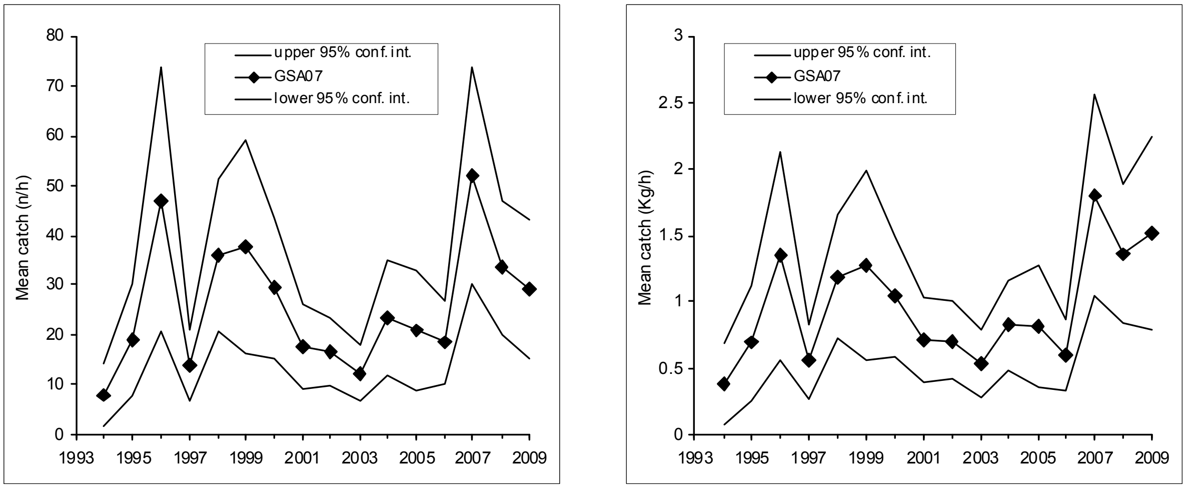


Fig. 5.19.3.1.3.1 Abundance and biomass indices of red mullet in GSA 07.

5.19.3.1.4. Trends in abundance by length or age

The following Fig. 5.19.3.1.4.1 and 2 display the stratified abundance indices of GSA 07 in 1994-2001 and 2002-2009.

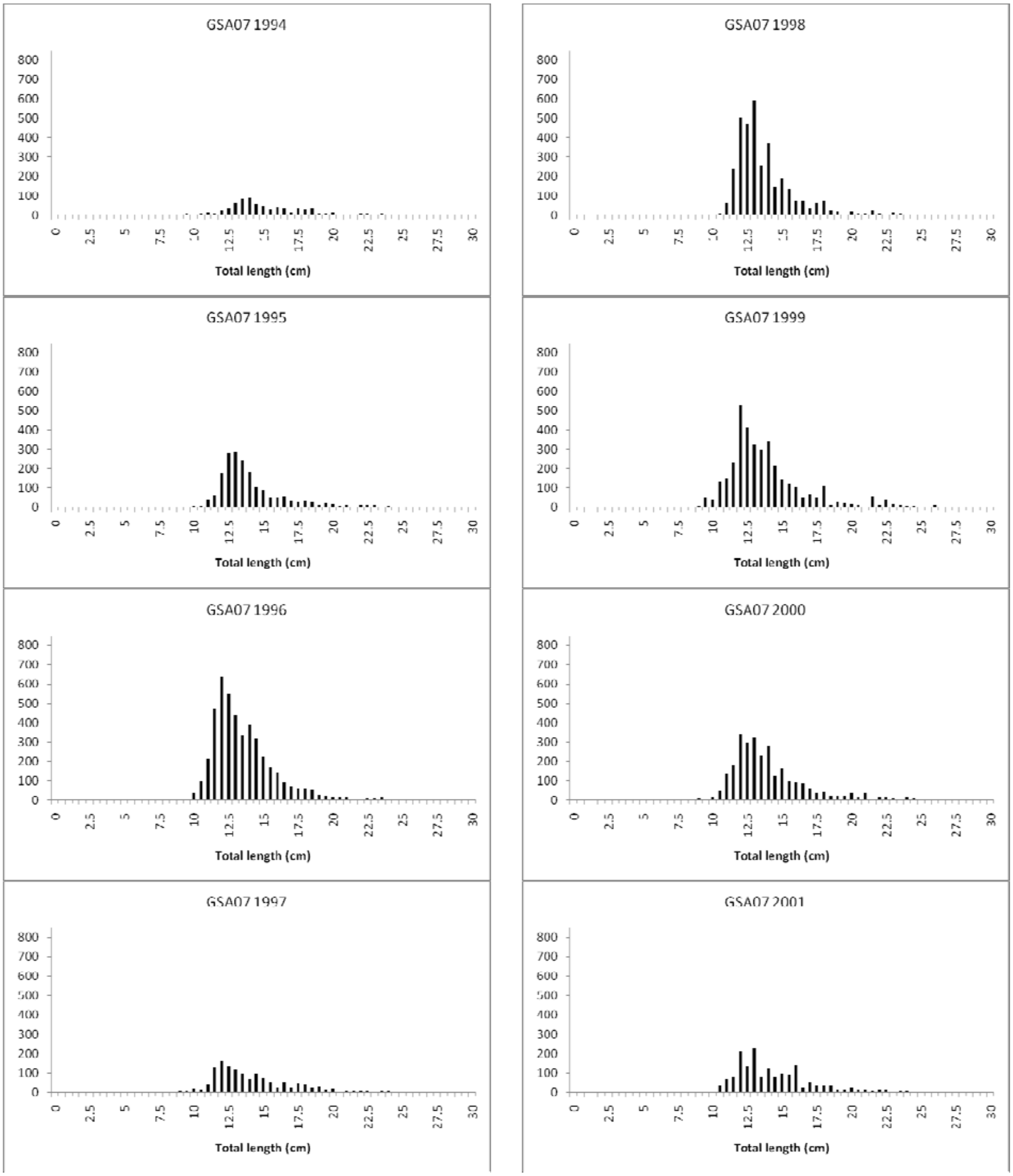


Fig. 5.19.3.1.4.1 Stratified abundance indices by size, 1994-2001.

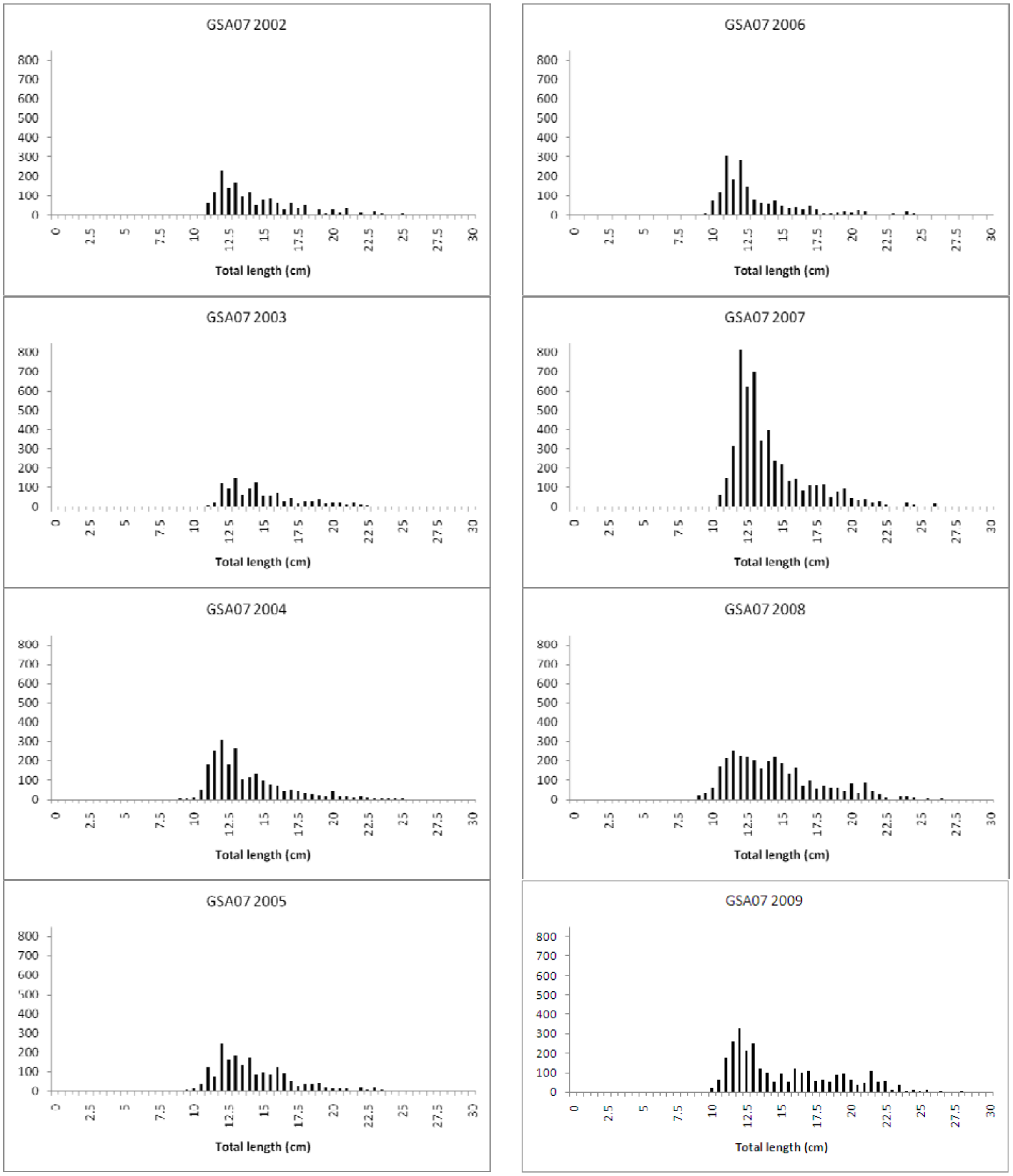


Fig. 5.19.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.19.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.19.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.19.4. Assessment of historic stock parameters

5.19.4.1. Method 1: VIT

5.19.4.1.1. Jusification

Because of the time series is short, we performed a LCA using the VIT software (Lleonart and Salat, 1994). SGMED-10-02 recommended performing both an LCA (VIT) for each individual year (2004-2009) together with a mean pseudo-cohort on the entire period. Ft was estimated using Fleda (Ft=0.526).

5.19.4.1.2. Input data

Data used derive from landings by length (Fig. 5.19.4.1.2.1) and were converted from length to age with VIT software (Fig. 5.19.4.1.2.2).

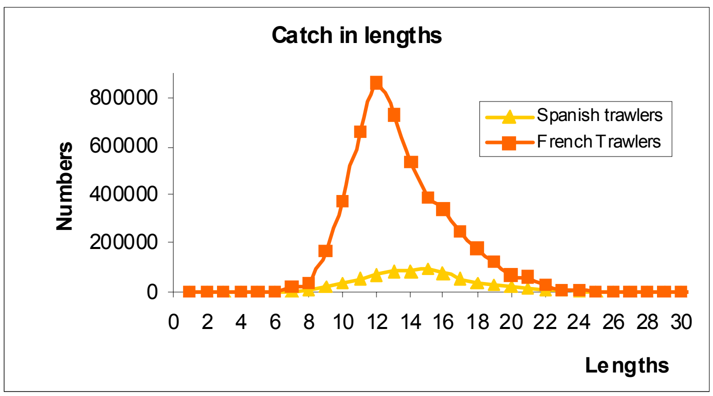


Figure 5.19.4.1.2.1. Catch in numbers per length (French and Spanish trawlers).

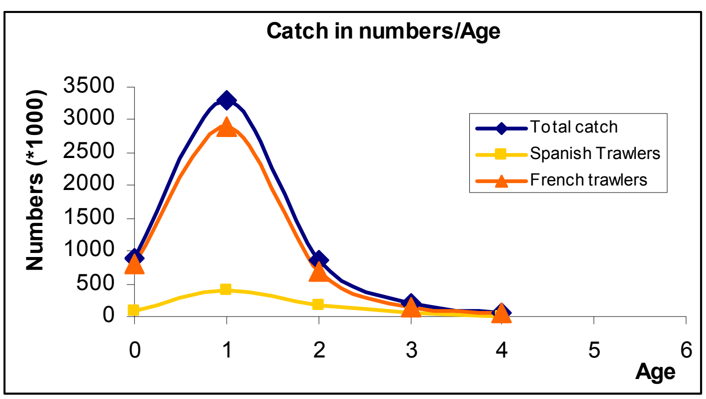


Fig. 5.19.4.1.2.2 Catch in numbers/Age (French and Spanish trawlers).

The parameters used are described in the tables 5.19.4.1.2.1, 2 and 3 below.

Tab. 5.19.4.1.2.1 Growth and length-weight (L-W) parameters (SGMED-08-03 GSA 07).

Growth parameters		Both
(Von Bertalanffy)	Linf (cm, total length)	26
	K	0.41
SGMED-08-03	T0	-0.4
L-W	a	0.0081
SGMED-08-03	b	3.113

Tab. 5.19.4.1.2.2 Natural mortality obtained using ProBIom (Abella et al., 1997).

Age	0	1	2	3	4	5+
M	0.64	0.43	0.27	0.18	0.15	0.12

Tab. 5.19.4.1.2.3 Maturity ogive (Spanish National Data Collection).

Age	0	1	2	3	4	5+
% of matures	0.00	0.17	0.61	0.89	0.96	0.99

5.19.4.1.3. Results including sensitivity

Results obtained using yearly analyses were very similar to those obtained with the mean pseudocohort, which validates the usefulness of pseudocohort analyses at least when data do not show important interannual variations. Recruitment was lowest in the last two years analysed (Figure 5.19.4.1.3.1), which might indicate a decreasing trend with time although the time series available is still too short to confirm this. F showed a slight decrease during the assessed period, in which the number of French trawls has decreased about 30%.

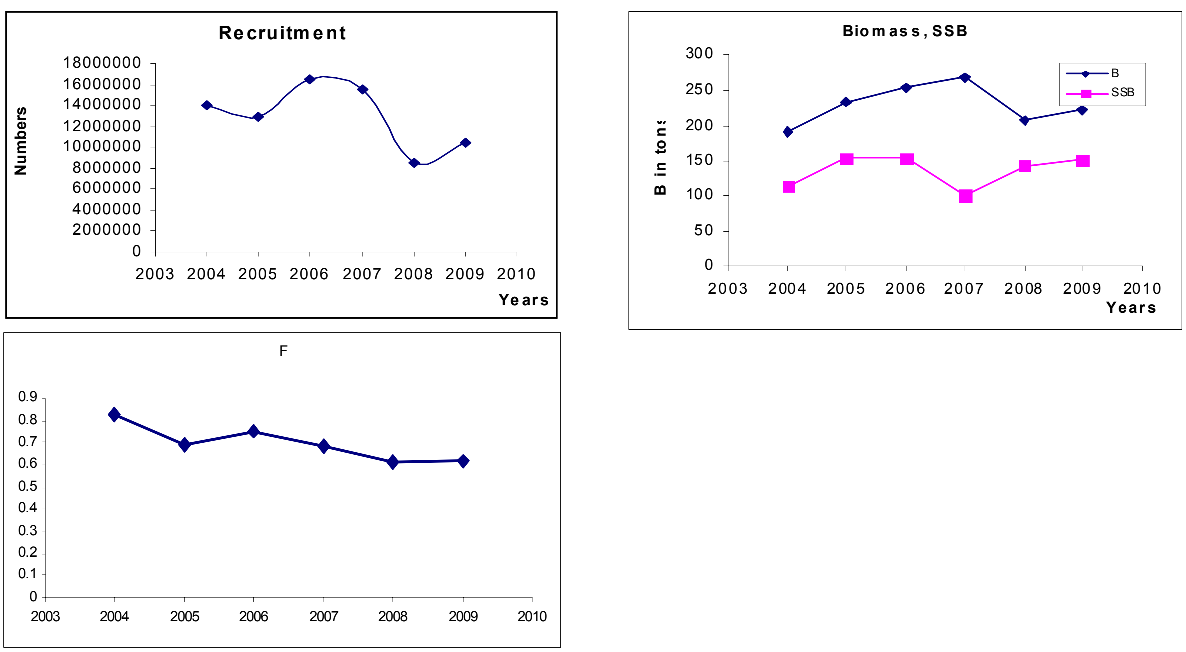
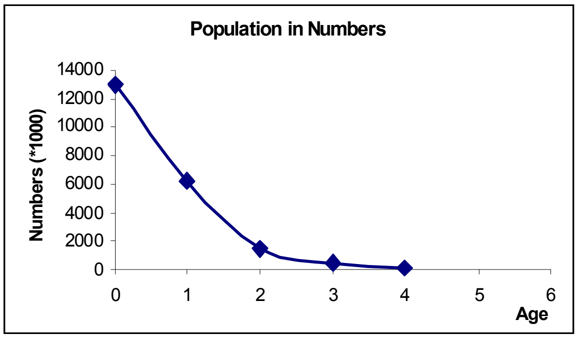


Fig. 5.19.4.1.3.1 Estimated trends in recruitment at age 0, SSB and fishing mortality as estimated by VIT.

Population in numbers is clearly higher in the 0 age class than in the rest of the ages, whereas population in biomass is dominated by ages 1 and 2 (Figure 5.19.4.1.3.2).



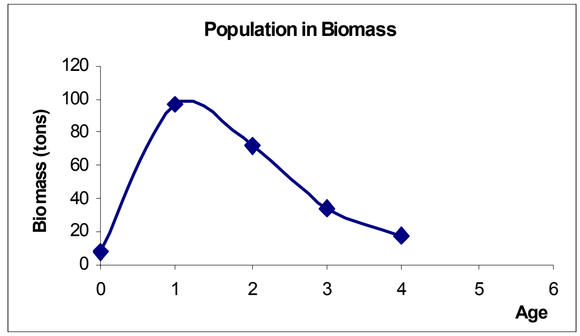


Figure 5.19.4.1.3.2 Average estimated population in numbers and biomass, 2003-2009.

The highest fishing mortalities are observed for ages 1 and 2 of French fleet, and 2 and 3 for Spanish fleet (Figure 5.19.4.1.3.3).

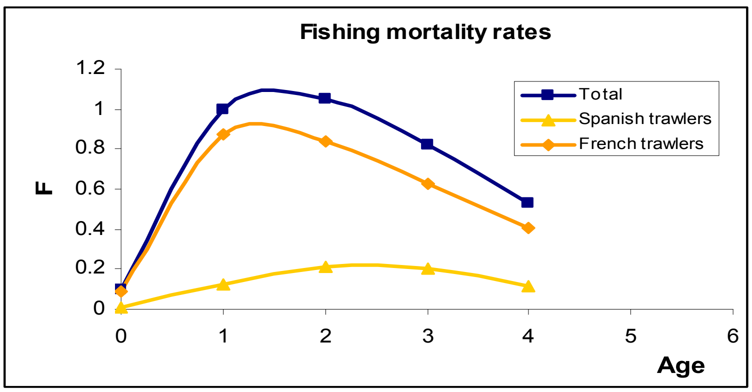


Figure 5.19.4.1.3.3 Average estimated fishing mortality over ages by fleets and total, 2003-2009.

5.19.5. Long term prediction

5.19.5.1. Justification

Yield per recruit analysis as provided by the VIT software was used for the estimation of F_{max} and $F_{0.1}$.

5.19.5.2. Input parameters

The input parameters for the Vit analysis are also used for the YpR analysis.

5.19.5.3. Results

Table 5.19.5.3.1 Fishing mortality (F current, F_{max} and $F_{0.1}$) for all the LCAs performed.

	2004	2005	2006	2007	2008	2009	Mean2004-2009
F	**0.83**	**0.693**	**0.752**	**0.682**	**0.611**	**0.619**	**0.698**
F(Sp Trawler)	0.147	0.118	0.167	0.131	0.112	0.116	0.131
F(Fr Trawler)	0.682	0.575	0.585	0.551	0.499	0.503	0.567
Fmax	**0.6**	**0.71**	**0.67**	**0.74**	**0.86**	**0.78**	**0.71**
F0.1	**0.41**	**0.49**	**0.44**	**0.51**	**0.58**	**0.54**	**0.49**

The stock is considered overexploited, the size of first capture is low (5 cm) for a sustainable fishing exploitation. Reduction of fishing effort and use of more selective gears should improve the yields (Figure 5.19.5.3.1)

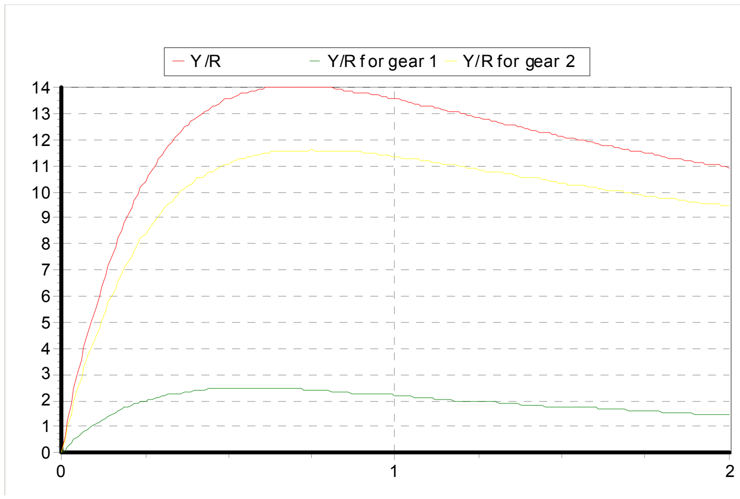


Figure 5.19.5.3.1 Yield per recruit (gear 1: Spanish trawlers ; gear 2: French trawlers).

5.19.6. Scientific advice

5.19.6.1. Short term considerations

5.19.6.1.1. State of the spawning stock size

In the absence of proposed precautionary and limit reference points SGMED is unable to fully evaluate the status of the stock of red mullet in GSA 07. Variation in SSB appears without any praticular trend. However, the recent survey abundance and biomass indices since 2007 appear high but are subject to high uncertainty.

5.19.6.1.2. State of recruitment

Variation in recruitment appears without any particular trend.

5.19.6.1.3. State of exploitation

SGMED-10-02 proposes $F_{0.1}$=0.5 as limit management reference point for exploitation consistent with high long term yield (F_{msy} proxy). Accordingly SGMED concludes that the stock of red mullet in GSA 07 is subject to overfishing. The 2009 estimate of fishing mortality suggest an effort reduction of around 20% for all fleets to achieve this management goal.

5.20. Stock assessment of red mullet in GSA 08

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.20.1. Stock identification and biological features

5.20.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.20.1.2. Growth

No information was documented during SGMED-10-02.

5.20.1.3. Maturity

No information was documented during SGMED-10-02.

5.20.2. Fisheries

5.20.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.20.2.2. Management regulations applicable in 2008 and 2009

No information was documented during SGMED-10-02.

5.20.2.3. Catches

5.20.2.3.1. Landings

No information was documented during SGMED-10-02.

5.20.2.3.2. Discards

No information was documented during SGMED-10-02.

5.20.2.3.3. Fishing effort

No information was documented during SGMED-10-02.

5.20.3. Scientific surveys

5.20.3.1. Medits

5.20.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. SGMED-09-02 notes that the reported Medits data in GSA 08 only cover the eastern coast of Corsica. In GSA 08 the following number of hauls was reported per depth stratum (s. Tab. 5.20.3.1.1.1).

Tab. 5.20.3.1.1.1. Number of hauls per year and depth stratum in GSA 08, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA08_010-050	3															
GSA08_050-100	5	5	7	3	7	6	5	5		6	6	7	7	5	7	5
GSA08_100-200	3	5	4	2	5	5	5	5	1	5	5	5	5	3	5	4
GSA08_200-500	9	11	12	8	12	10	11	10		10	10	10	11	8	12	12
GSA08_500-800	5	5	4	4	4	5	4	5		4	5	5	4	5	4	3

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.20.3.1.2. *Geographical distribution patterns*

No analyses were conducted during SGMED-10-02.

5.20.3.1.3. *Trends in abundance and biomass*

Fishery independent information regarding the state of the red mullet in GSA 08 was derived from the international survey Medits. SGMED-09-02 notes that the reported Medits data in GSA 08 only cover the eastern coast of Corsica. Figure 5.20.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 08.

The estimated abundance and biomass indices do not reveal any significant trends since 1994. However, the recent abundance and biomass indices since 2007 appear very low. The analyses of Medits indices are considered preliminary.

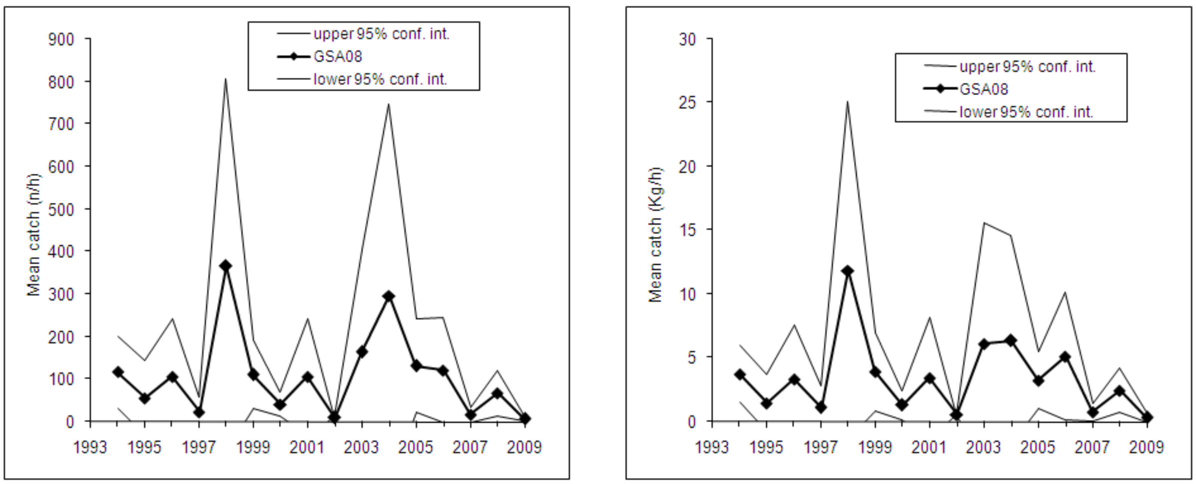


Fig. 5.20.3.1.3.1 Abundance and biomass indices of red mullet in GSA 08.

5.20.3.1.4. *Trends in abundance by length or age*

The following Fig. 5.20.3.1.4.1 and 2 display the stratified abundance indices of GSA 08 in 1994-2001 and 2002-2009.

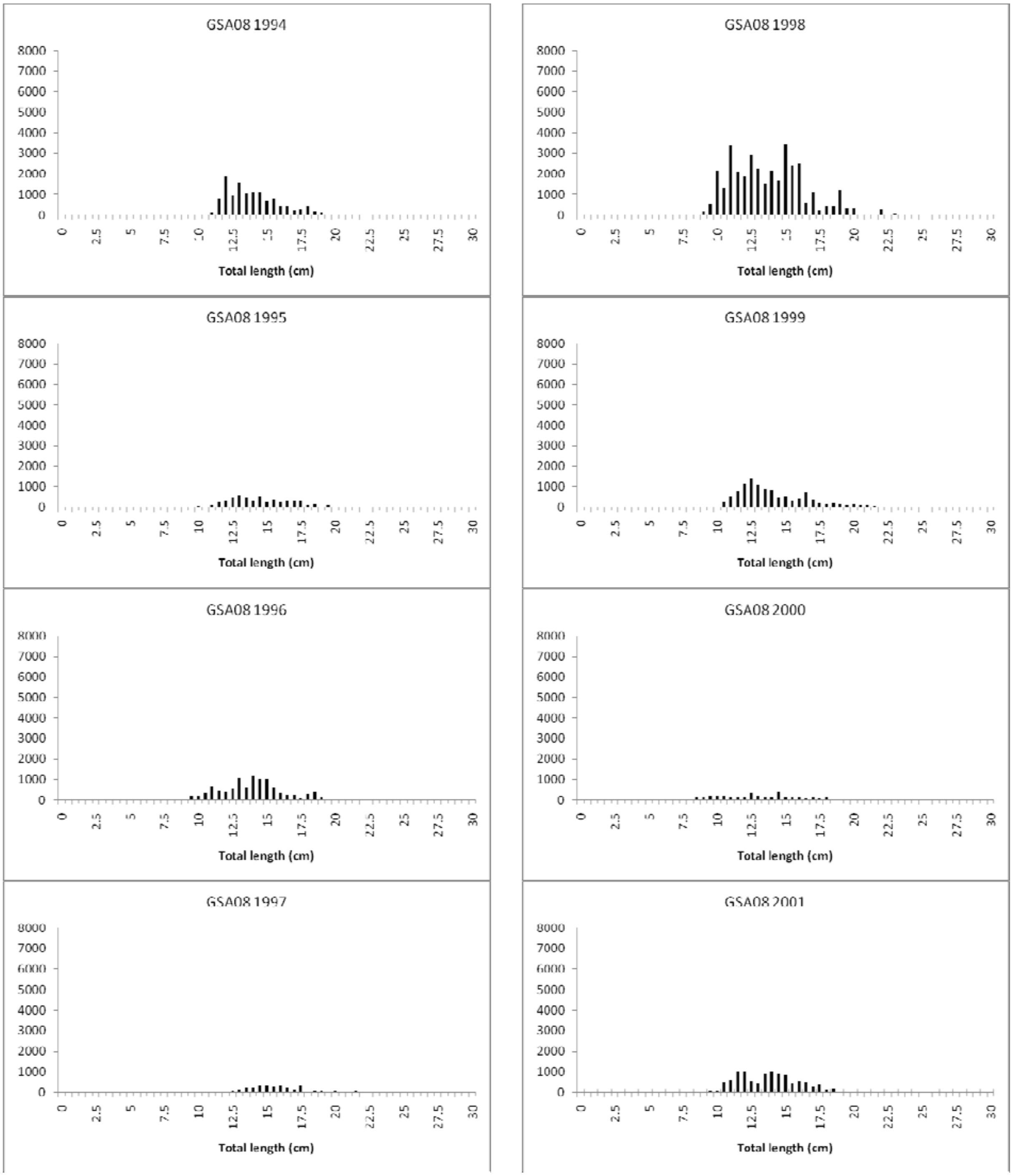


Fig. 5.20.3.1.4.1 Stratified abundance indices by size, 1994-2001.

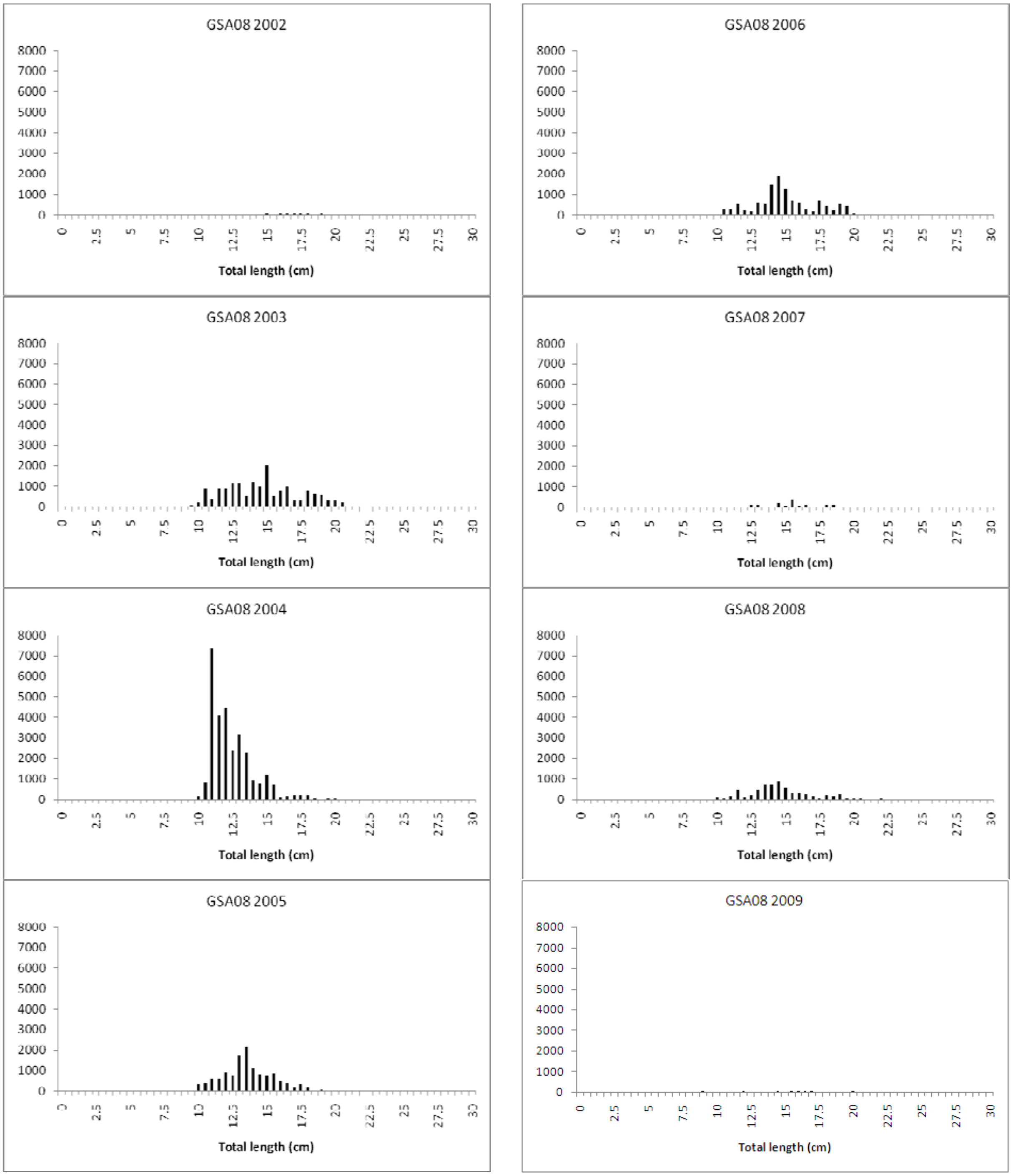


Fig. 5.20.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.20.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.20.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.20.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.20.5. Long term prediction

5.20.5.1. Justification

No forecast analyses were conducted.

5.20.5.2. Input parameters

No forecast analyses were conducted.

5.20.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for red mullet in GSA 08.

5.20.6. Scientific advice

5.20.6.1. Short term considerations

5.20.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses. Since 2007, stock biomass is incidated to be low.

5.20.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.20.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation in relation to proposed precautionary and target levels given the preliminary state of the data and analyses.

5.21. Stock assessment of red mullet in GSA 09

5.21.1. Stock identification and biological features

5.21.1.1. Stock Identification

The species can be found at depths over 200 m, but is mainly concentrated in the depth range 0-100 m, along the narrow Mediterranean shelves. There is not any available definition of stock unit neither based on genetics, bio-chemistry, fishery-based information nor any other method related to somatic features. Under the framework of GFCM, it has been decided that, in the absence of any evidence suggesting an alternative hypothesis, a single, homogeneous well-mixed and self-perpetuating stock inhabits each GSAs . The GSA boundaries are however arbitrary and do not take into consideration neither the existence of any local biological feature nor any difference in the spatial allocation of the fishing pressure. The hypothesis of a single stock of red mullet in GSA 09, which includes waters belonging to two seas (Ligurian and Tyrrhenian) separated by the Elba Island with fleets that does not show any spatial overlapping, is unlikely. The inability to account for the spatial structure can lead to uncertainty in the definition of the status of the stocks, due to the possibility of local depletions, and therefore to a poor utilization of the potential productivity of the resources.

5.21.1.2. Growth

The species is fast growing, and reaches half of its total size during the first year of life. Some light differences in growth rate has been observed within different zones of GSA 09. Where the species is less exploited, individuals more densely concentrated or available food limited, the mean size of individuals is lower than in other areas of the same GSA were the species is more highly exploited and hence less abundant. In any case, the parameters reported here are considered appropriate for the description of an average growth performance of the species in the whole GSA 09.

Table 5.21.1.2.1 Common growth parameters considered representative for *M. barbatus* in the GSA 09 utilized in the successive analyses.

Linf=29, K=0.6, t_0=-0.1
L/W relationship a=0.00053 b=3.12
An M vector (age1=1.30, age2 0.79, age 3 0.62, age 4= 0.54) and a weighted mean value of M of 0.8

5.21.1.3. Maturity

The species reaches the sexual maturity at age 1. Observations of proportion of mature individuals by size and analysis with the standard procedure have produced the following sizes at age maturity by sex.

L_m	12.5 cm TL (females) 10 cm TL (males	Sanchez *et al*. 1995

The classical approach for the definition of Lm, as expected, produces a light underestimation of this size. In fact, the bulk of the females spawn at a size of about 14 cm.

The following relationship of fecundity at size (in cm) was defined for GSA 09:
Fec= 0.7599·TL^3.336

5.21.2. Fisheries

5.21.2.1. General description of fisheries

STECF (SGRST stock review part II 2009) noted that *Mullus barbatus is* among the most commercially valuable species in the area. It is caught mainly with three different variants of the bottom trawl net. *Mullus barbatus* catches are higher during the postrecruitment period (from September to November). About 350 trawlers and a small number of artisanal vessels exploit the species. Annual landings are around 700 t, mostly from trawlers. Catch is mainly composed by age 0 individuals while the older age classes are poorly represented in the catch. Illegal (undersized) catches of juveniles do occur.

L_c	7.4 cm TL (males + females)	De Ranieri *et al.* , 2000

Set nets catch modest quantitatives of relatively large individuals, in general over 12 cm TL. The exerted fishing pressure on this species on different zones of GSA 09 is quite variable. It is affected by the structural composition of the part of the fleet that operate close to their respective ports, by the characteristics of those bottoms potentially exploitable and also by differences in the fisheries' target among fleets and zones. Discards of undersized individuals is in general limited (was about 10% in weight in 2006), mainly due to the fact that immediately after recruitment, small-sized individuals, even though potentially vulnerable to the gear, are mostly concentrated inside the 3 miles where trawling is forbidden. Illegal catches of juveniles within this area, may occur, but it can be considered of limited importance.

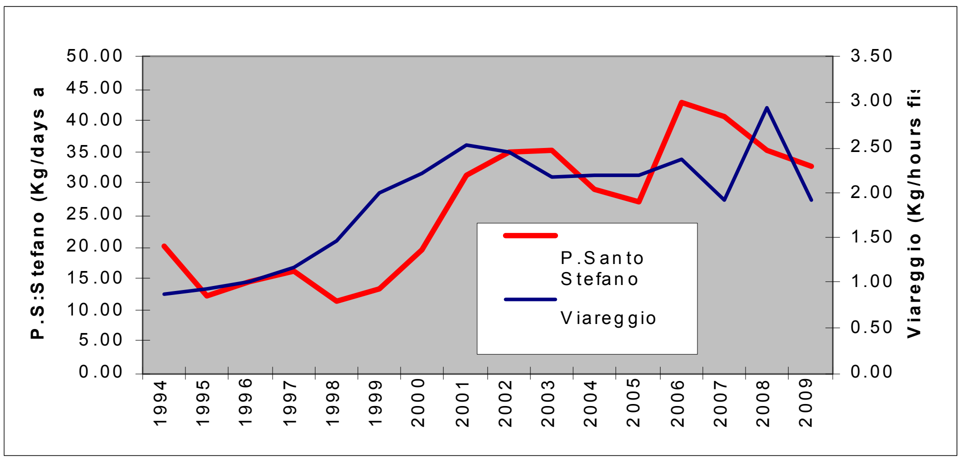


Fig. 5.21.2.1.1 Landings per unit of effort by year in two of the more important ports of GSA 09.

5.21.2.2. Management regulations applicable in 2009 and 2010

Fishing closure for trawling: A fishing ban of 45 days in late summer have been enforced in certain years for some fleets in GSA9. In 2008 and 2009 was compulsory for all the trawlers in the area.

Minimum landing sizes: EC regulation 1967/2006 defined 11 cm TL as minimum legal landed size for red mullet.

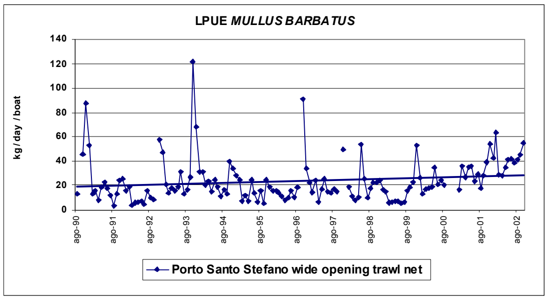
Cod end mesh size of trawl nets: the 40 mm (stretched, diamond meshes) will continue to be utilized up to 30/05/2010. Since 1/6/2010, such cod end will be replaced by a 40 mm square meshes or alternatively by a net with a cod end of 50 mm (stretched) diamond meshes. It is not expected a noticeable increase in the size of entering to the fishery with the introduced changes because this size is only patially defined by the gear but also by the spatial distribution of juveniles.

Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

5.21.2.3. Catches

5.21.2.3.1. Landings

Landings data were reported to SGMED through the Data collection regulation. Landings from 2009 were not submitted by the Italian authorities. Since 2002 annual landings varied between 620 and 1,100 tons (Tab. 5.21.2.3.1.1). Demersal bottom trawlers dominate the landings. Landings size show a very high seasonal variability, with peaks at the end of summer (September) determined by the increase in availability/vulnerability of the species after the massive recruitment on the coastal area.



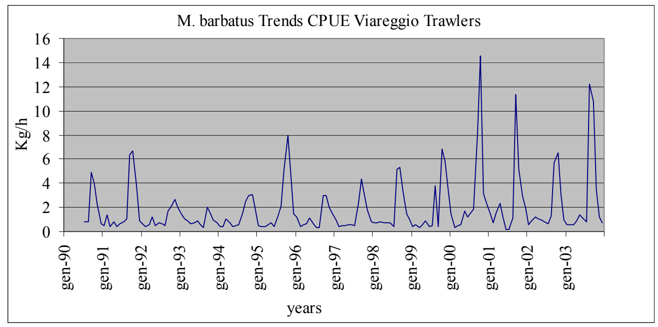


Fig. 5.21.2.3.1.1 Monthly catches with regular seasonal fluctuations in red mullet landings in two of the main ports of GSA 09.

Table 5.21.2.3.1.1 Annual landings (t) by fishing technique as reported to SGMED-10-02 through the DCF data call in 2009.

YEAR	Bottom trawls	Nets	Total catch (Tons)
2004	521.1	59.9	583.2
2005	684.0	30.8	714.9
2006	1033.2	16.4	1050.1
2007	1087.4	8.6	1096.0
2008	716.3	11.2	727.4

Table 5.21.2.3.1.2 Annual landings (t) by fishing technique as reported to SGMED-10-02 through the DCF data call in 2010.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	9	ITA						2	1	0			
MUT	9	ITA	GND	SPF						0			
MUT	9	ITA	GNS	DEMSP				21	16	3	3	3	
MUT	9	ITA	GNS	SLPF								0	
MUT	9	ITA	GTR	DEMSP				39	8	13	6	7	
MUT	9	ITA	LLD	LPF				0					
MUT	9	ITA	LLS	DEMF					5			0	
MUT	9	ITA	OTB	DEMSP				245	130	359	507	636	
MUT	9	ITA	OTB	DWSP								1	
MUT	9	ITA	OTB	MDDWSP				276	554	674	580	79	
MUT	9	ITA	PS	SPF				0					
Sum								583	714	1049	1096	726	

Artisanal fisheries target bigger individuals, but their landings is neglegible.

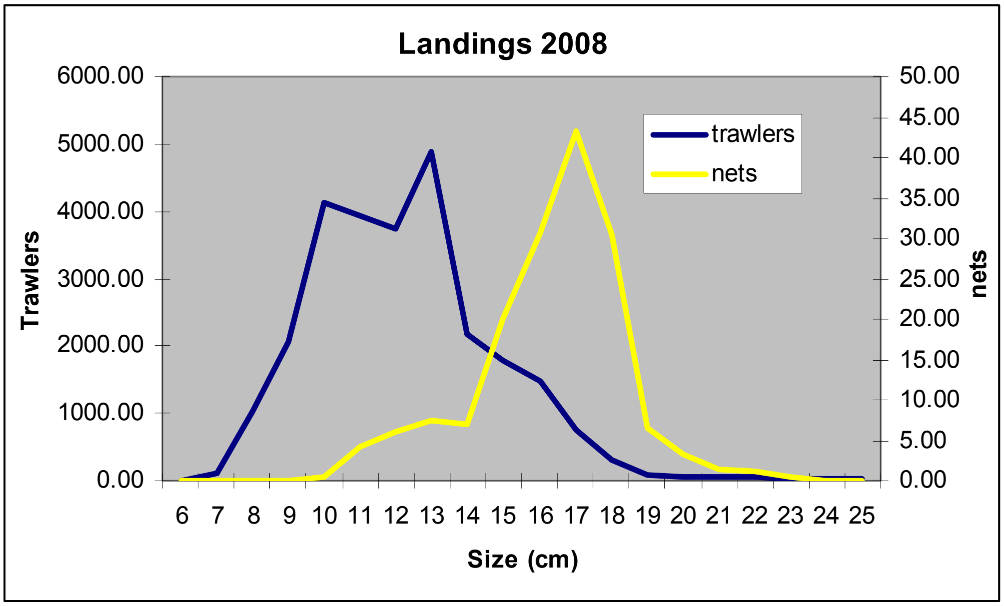


Fig. 5.21.2.3.1.2 Composition of the commercial catches in numbers (Official data).

Table 5.21.2.3.1.3 Size structure of landings for trawlers and artisanal fleet for years 2006-2008.

	2006		2007		2008	
size (cm)	trawlers	nets	trawlers	nets	trawlers	nets
6	0.00	0.00	5.27	0.00	0.00	0.00
7	19.34	0.00	49.31	0.00	115.70	0.00
8	85.03	0.00	90.98	0.00	1023.94	0.00
9	456.91	0.00	391.35	0.00	2068.53	0.00
10	1283.77	5.44	738.57	0.00	4119.06	0.45
11	1715.53	28.54	1382.01	0.00	3933.30	4.09
12	2135.28	32.51	2606.97	0.00	3725.83	6.00
13	2795.66	32.16	3164.87	10.32	4887.99	7.55
14	2984.35	8.31	2558.87	34.58	2174.50	6.92
15	2714.90	11.72	3202.84	44.83	1777.36	19.92
16	1928.88	13.82	2374.11	30.74	1486.53	30.66
17	1603.74	15.04	2058.54	37.40	763.75	43.17
18	1206.94	11.51	1634.75	57.66	317.98	30.52
19	1445.07	7.52	1081.34	8.15	88.10	6.60
20	1230.68	3.62	595.52	5.94	54.49	3.30
21	544.97	4.05	317.92	3.80	65.28	1.37
22	140.28	3.78	187.45	23.42	47.20	1.10
23	51.03	3.57	129.83	0.11	30.01	0.55
24	36.54	0.73	49.88	0.57	28.93	0.00
25	39.75	0.00	26.47	0.00	28.93	0.00

5.21.2.3.2. Discards

158 t of discards in 2006 were reported to SGMED-09-02.

5.21.2.3.3. Fishing effort

Tab. 5.21.2.3.3.1 lists the effort by fishing technique deployed in GSA 09 as reported to SGMED-10-02 through the DCR data call. A minor decrease is observed for the main gear demersal otter trawl. It is however difficult to extract from these figures the real number of vessels that target red mullet.

In the last 15 years, a general decrease in the size of the fishing fleets operating in the GSA 09 targeting demersal species was observed. The number of vessels targeting the species in question and the changes (reduction) in number along the time interval 1990-2007 occurred for some ports of the GSA. The reduction of number of vessels has been particularly important in Porto Santo Stefano fleet in the South (about 50% of reduction) and in Viareggio in the North (about 30%). It is likely that this general reduction in numbers of vessels also apply for the fraction of the fleet that exerts its fishing effort on *M. barbatus*.

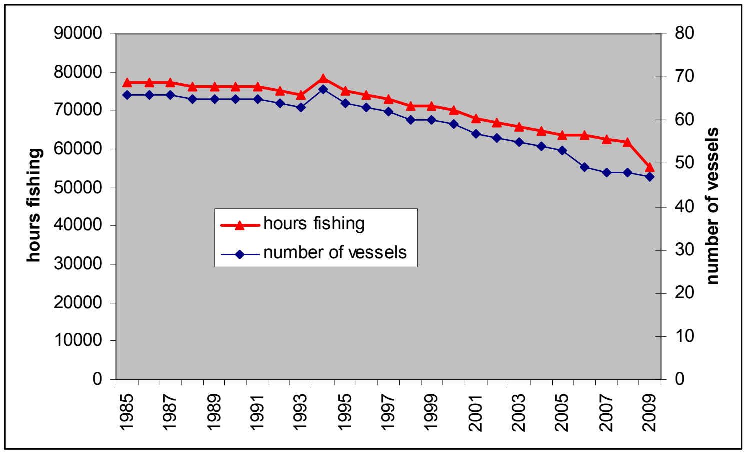


Fig. 5.21.2.3.3.1 Number of vessels and fishing activity in the port of Viareggio (1985-2009).

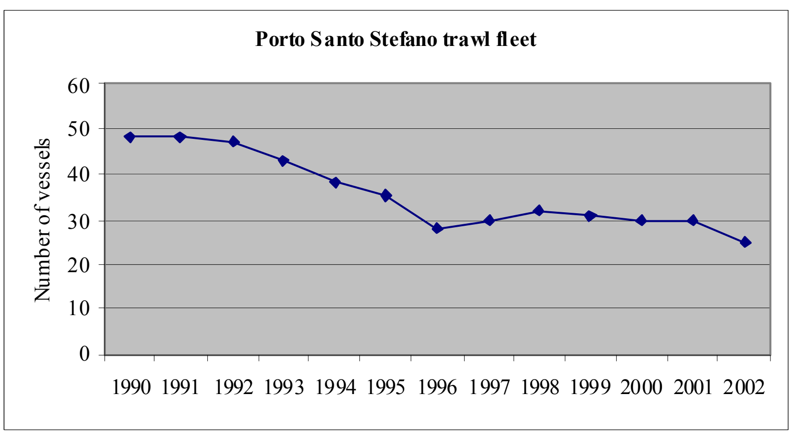


Fig. 5.21.2.3.3.2 Number of vessels in the port of Porto Santo Stefano (1990-2002).

Tab. 5.21.2.3.3.1 Effort trends by fishing technique in GSA 09, 2004-2008. Data regards the whole fleets by fishing typology without any distinction regarding targets, season nor operations depth interval).

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008
9	ITA				VL0006					296	
9	ITA				VL0612		31025	45782	71302	4865	12129
9	ITA	DRB	MOL		VL1218		18652	20370	13504	29808	28266
9	ITA	GNS	DEMSP		VL0006				14365	9687	7681
9	ITA	GNS	DEMSP		VL0612		204925	219978	146971	201390	146006
9	ITA	GNS	DEMSP		VL1218		100498	59006	49194	62666	67944
9	ITA	GNS	SLPF		VL0612		4857				3707
9	ITA	GTR	DEMSP		VL0006				1417	4451	
9	ITA	GTR	DEMSP		VL0612		75571	121141	100767	142363	43116
9	ITA	GTR	DEMSP		VL1218		3222	19168	11102	14510	6610
9	ITA	LLD	LPF		VL0612		6569	17394	3581	5904	25890
9	ITA	LLD	LPF		VL1218		1611	4427	24956	5535	12094
9	ITA	LLS	DEMF		VL0612		37454	75215	18823	4330	
9	ITA	LLS	DEMF		VL1218		3914	9998			
9	ITA	LTL	LPF		VL0006				3198	687	
9	ITA	OTB	DEMSP		VL0612		7282	6524	15126	21176	14595
9	ITA	OTB	DEMSP		VL1218		118419	113284	77407	171295	221969
9	ITA	OTB	DEMSP		VL1824		515183		69690	200680	478813
9	ITA	OTB	DEMSP		VL2440		125282				
9	ITA	OTB	MDDWSP		VL1218		151739	183842	177083	158561	57869
9	ITA	OTB	MDDWSP		VL1824		85625	737780	692516	404814	75728
9	ITA	PS	SPF		VL0612			10014			
9	ITA	PS	SPF		VL1218			3703			
9	ITA	PS	SPF		VL1824		6526	6055			
9	ITA	SB-SV	DEMSP		VL0006				3780	3664	4506
9	ITA	SB-SV	DEMSP		VL0612		127810	191056	133213	74903	62000
9	ITA	SB-SV	DEMSP		VL1218		22438	10582	13566	2988	5196

5.21.3. Scientific surveys

5.21.3.1. Medits

5.21.3.1.1. Methods

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 09 the following number of hauls was reported per depth stratum (s. Tab. 5.21.3.1.1.1).

Tab. 5.21.3.1.1.1. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA09_010-050	19	18	18	18	19	18	18	18	13	13	13	14	13	13	13	14
GSA09_050-100	19	20	18	19	18	19	20	20	15	15	15	14	16	16	13	14
GSA09_100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	28	27
GSA09_200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	30	28
GSA09_500-800	31	30	31	28	30	28	27	29	24	22	21	20	20	17	18	20

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.21.3.1.2. Geographical distribution patterns

The species is distributed all along the continental shelf of the GSA 09, with the largest abundance in the depth range 0-100 m. The species is highly concentrated along the coastal area between 0-30 m when in late summer-beginnings of autumn juveniles settle to the bottom. The major nursery areas are allocated in the northern portion of the GSA, northwards of the Elba Island (yellow areas in Fig. 5.21.3.1.2.1).

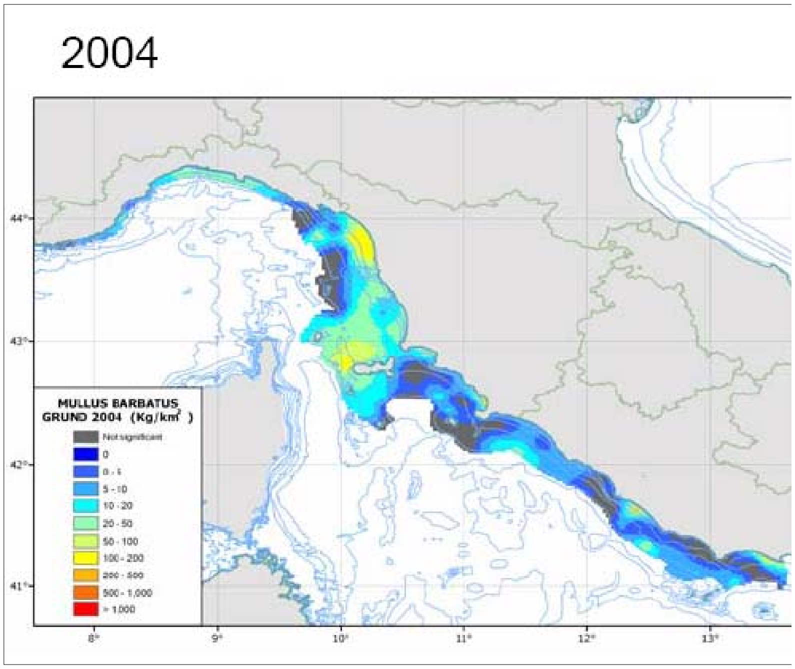


Fig. 5.21.3.1.2.1 Distribution of juveniles of red mullet in autumn 2004 (GRUND survey) in kg·km^{-2}.

Also mature individuals are more abundant in the Northern part of the GSA 09.

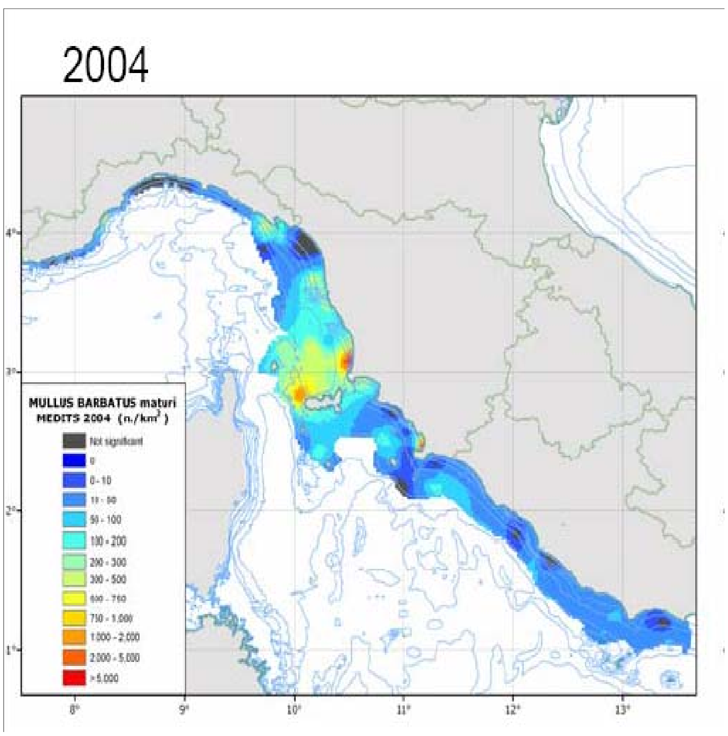


Fig. 5.21.3.1.2.2 Distribution of mature adults of red mullet in spring 2004 (MEDITS survey) in numbers·km^{-2}.

The nursery concentrations show a marked spatial stability. Fig. 5.21.3.1.2.3 shows the areas where a major persistency along time has been observed (in dark brown).

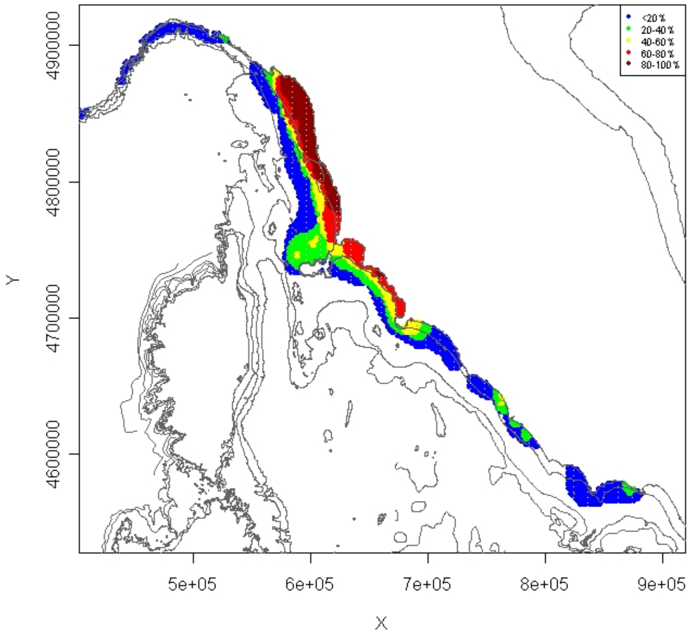


Fig 5.21.3.1.2.3 Persistency of *Mullus barbatus* concentrations.

5.21.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 09 was derived from the international survey MEDITS. Figure 5.21.3.1.3.1 shows the estimated trends in the biomass index. The estimated biomass indices suggest an increasing trend (from 7.3 to 24 kg·km^{-2} in 2002 and a stable trend in the recent years with values ranging between 15 and 20 kg·km^{-2}.

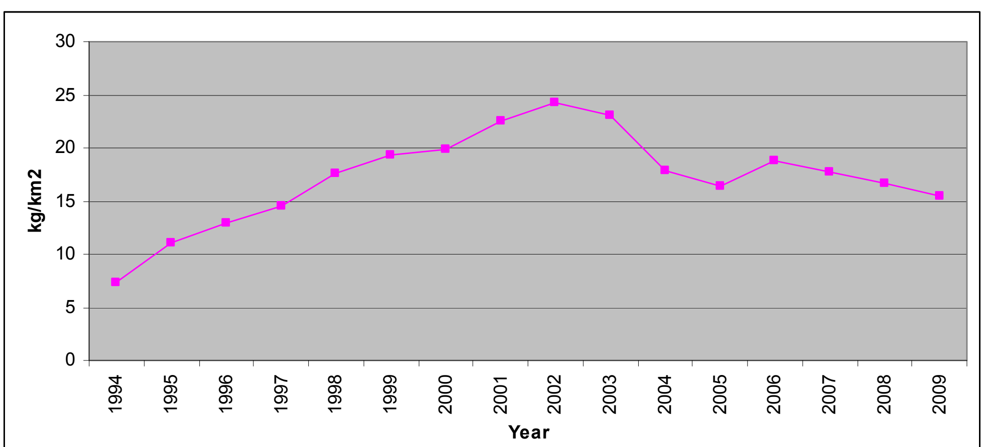


Fig. 5.21.3.1.3.1 Biomass indices derived from MEDITS for red mullet in GSA 09.

Figure 5.21.3.1.3.2 displays the estimated trends in abundance and biomass derived from the international surveys Medits. The estimated abundance and biomass indices do not reveal any significant trend since 1994. Recent indices vary among an average level.

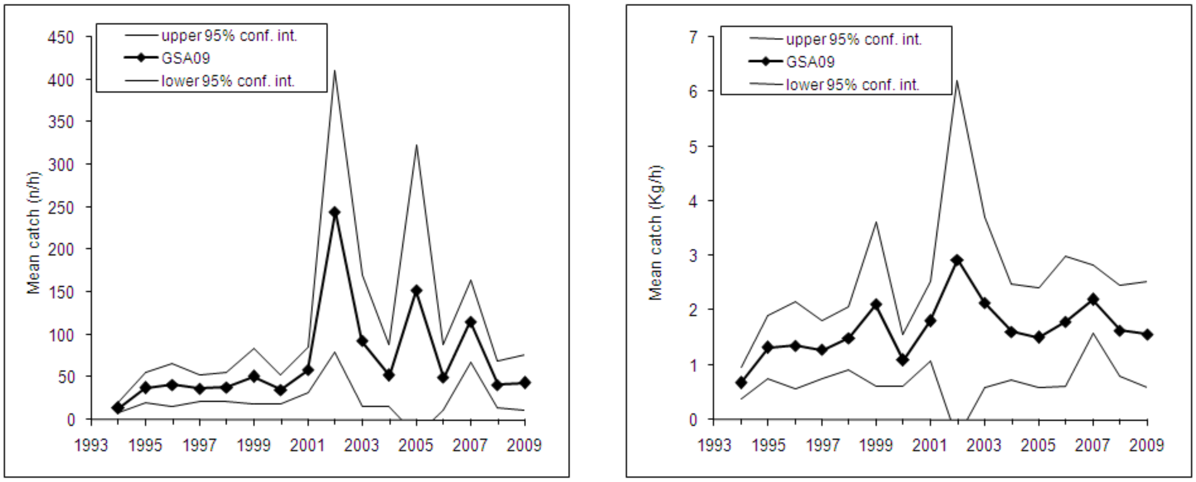


Fig. 5.21.3.1.3.2 Abundance and biomass indices of red mullet in GSA 09 derived from MEDITS.

5.21.3.1.4. Trends in abundance by length or age

The following Fig. 5.21.3.1.4.1 and 2 display the stratified abundance indices of GSA 09 in 1994-2001 and 2002-2009.

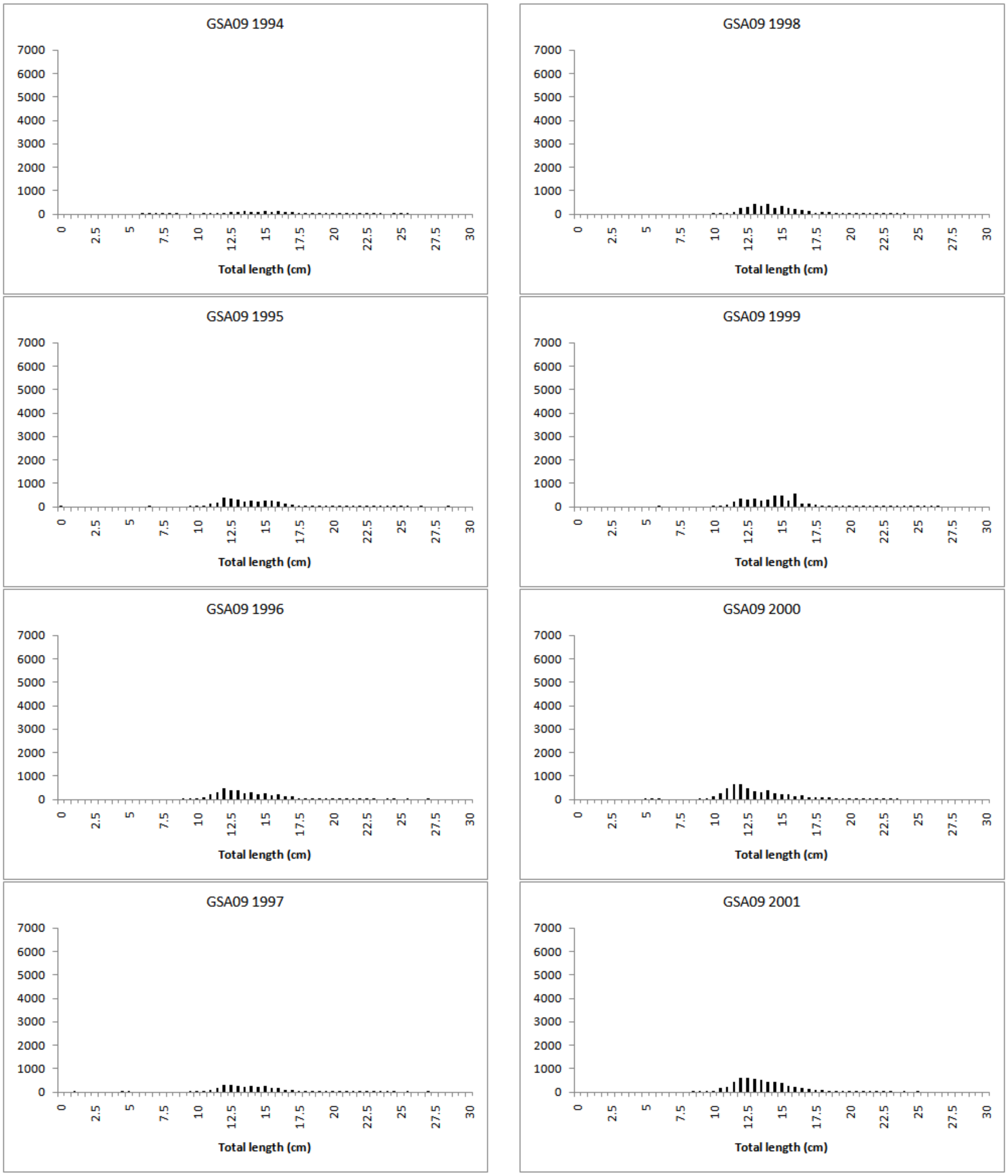


Fig. 5.21.3.1.4.1 Stratified abundance indices by size, 1994-2001.

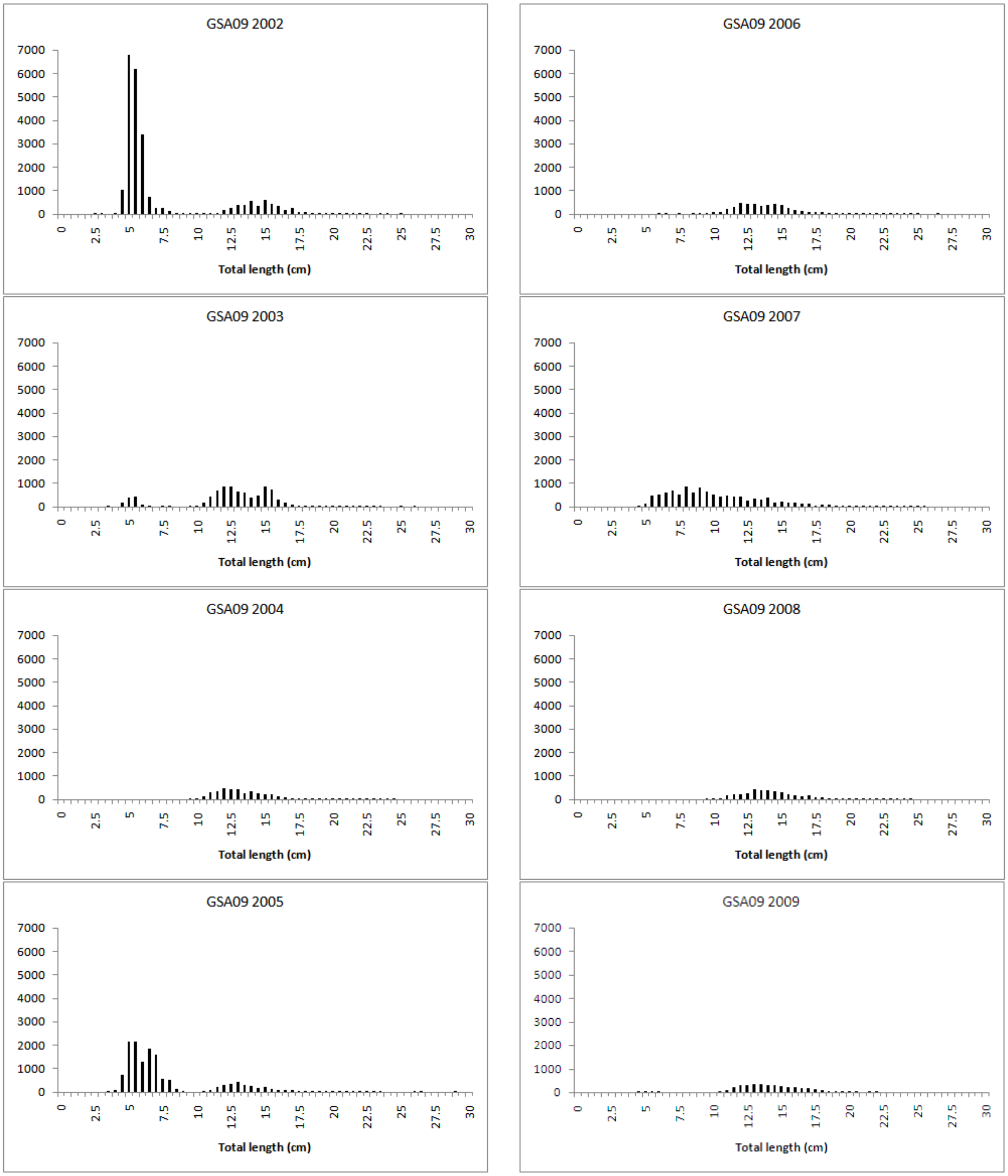


Fig. 5.21.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.21.3.1.5. Trends in growth

No analyses were conducted.

5.21.3.1.6. Trends in maturity

No analyses were conducted.

5.21.4. Assessment of historic stock parameters

5.21.4.1. Method 1: Stock-Production model

5.21.4.1.1. Justification

The analysis was performed using the ASPIC.5.3 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a non-equilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate K, MSY, the ratios of both current biomass or F to the biomass or F at which MSY can be attained, and q (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

5.21.4.1.2. Input parameters

Input data consist in 2 sets of time series of total landings (in kg) and fishing effort expressed as kg·hour^{-1} and kg·day^{-1} for two of the main ports of the GSA 09 (Viareggio and Porto Santo Stefano) which are considered representative for the area and a time series of an index of abundance (kg·km^{-2}) for the whole GSA 09 derived from MEDITS surveys. The possibility of using at the same time several data sets is a new extension incorporated in the ASPIC new versions.

```
BOT                  ## Run type (FIT, BOT, or IRF)
"None Selected"
LOGISTIC YLD SSE   ## Model type, conditioning type, objective function
102                  ## Verbosity
500                  ## Number of bootstrap trials, <= 1000
1 50000              ## 0=no MC search, 1=search, 2=repeated srch; N trials
1.00000d-08          ## Convergence crit. for simplex
3.00000d-08   6      ## Convergence crit. for restarts, N restarts
1.00000d-04   0      ## Convergence crit. for estimating effort; N steps/yr
8.00000d00           ## Maximum F allowed in estimating effort
0d0            ## Weighting for B1 > K as residual (usually 0 or 1)
3                ## Number of fisheries (data series)
1.00000d00  1.00000d00  1.00000d00           ## Statistical weights for data series
4.00000d-01          ## B1/K (starting guess, usually 0 to 1)
3.50000d05           ## MSY (starting guess)
2.50000d06           ## K (carrying capacity) (starting guess)
5.00000d-04  8.00000d-04  4.00000d-04           ## q (starting guesses -- 1 per data series)
1 1 1 1 1 1          ## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
1.50000d05  1.00000d06          ## Min and max constraints -- MSY
4.00000d05  1.00000d07          ## Min and max constraints -- K
657438223            ## Random number seed
      16             ## Number of years of data in each series

      Series 1" Porto Santo Stefano
CE
  1994   1.92800d03   3.90290d04
  1995   2.25000d03   2.73570d04
  1996   2.32000d03   3.36430d04
  1997   2.13700d03   3.47150d04
  1998   2.62600d03   3.00910d04
  1999   2.45400d03   3.31610d04
  2000   2.35400d03   4.60630d04
  2001   1.53200d03   4.80690d04
```

2002	1.17400d03	4.09930d04
2003	1.44800d03	5.10270d04
2004	1.59100d03	4.60480d04
2005	1.47500d03	5.19490d04
2006	1.62900d03	5.75110d04
2007	1.55000d03	6.09360d04
2008	1.42300d03	5.34110d04
2009	1.44900d03	5.03960d04

"Series 2" Viareggio
CE

1994	7.83750d04	6.96500d04
1995	7.52400d04	7.13260d04
1996	7.41950d04	7.46630d04
1997	7.31500d04	8.51100d04
1998	7.10600d04	1.04051d05
1999	7.10600d04	1.41873d05
2000	7.00150d04	1.54654d05
2001	6.79250d04	1.70953d05
2002	6.68800d04	1.63647d05
2003	6.58350d04	1.43018d05
2004	6.47900d04	1.42679d05
2005	6.37450d04	1.44629d05
2006	6.35560d04	1.37005d05
2007	6.26320d04	1.50682d05
2008	6.17260d04	1.35800d05
2009	5.54030d04	1.20991d05

"Series 3" MEDITS trawl surveys
I1

1994	7.35060d00
1995	1.10108d01
1996	1.29917d01
1997	1.45988d01
1998	1.76335d01
1999	1.92935d01
2000	1.98471d01
2001	2.25128d01
2002	2.42151d01
2003	2.30405d01
2004	1.79391d01
2005	1.64171d01
2006	1.88141d01
2007	1.77500d01
2008	1.66300d01
2009	1.54800d01

5.21.4.1.3. Results

Tuesday, 01 Jun 2010 at 13:20:51
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.16)
FIT program mode
Author: Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research LOGISTIC model mode
101 Pivers Island Road; Beaufort, North Carolina 28516 USA YLD conditioning
Mike.Prager@noaa.gov SSE optimization

Reference: Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fishery Bulletin 92: 374-389.
ASPIC User's Manual is available gratis from the author.

CONTROL PARAMETERS (FROM INPUT FILE) Input file: c:\abella\aspic5\mbar09proveconoriginale.inp

----

Operation of ASPIC: Fit logistic (Schaefer) model by direct optimization.

Number of years analyzed:	16	Number of bootstrap trials:	0	
Number of data series:	3	Bounds on MSY (min, max):	1.500E+05	1.000E+06
Objective function:	Least squares	Bounds on K (min, max):	4.000E+05	1.000E+07
Relative conv. criterion (simplex):	1.000E-08	Monte Carlo search mode, trials:	1	50000

Relative conv. criterion (restart):	3.000E-08	Random number seed:	657438223
Relative conv. criterion (effort):	1.000E-04	Identical convergences required in fitting:	6
Maximum F allowed in fitting:	8.000		

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) ------------------------
----

Normal convergence
Number of restarts required for convergence: 590

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

	1	2	3
1 Series 1	1.000		
	16		
2 Series 2	0.772	1.000	
	16	16	
3 Series 3	0.448	0.812	1.000
	16	16	16

GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Inv. var. weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1 > K	0.000E+00	1	N/A	0.000E+00	N/A	
Loss(1) Series 1	1.935E+00	16	1.382E-01	1.000E+00	1.906E-01	0.396
Loss(2) Series 2	1.941E-01	16	1.386E-02	1.000E+00	1.900E+00	0.868
Loss(3) Series 3	4.056E-01	16	2.897E-02	1.000E+00	9.091E-01	0.567

TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 2.53476886E+00 6.035E-02 2.457E-01

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1994)	1.198E-01	4.000E-01	5.604E-01	1	1
MSY	Maximum sustainable yield	2.553E+05	3.500E+05	3.200E+05	1	1
K	Maximum population size	7.960E+05	2.500E+06	8.654E+05	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	2.553E+05	----	----
Bmsy	Stock biomass giving MSY	3.980E+05	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	6.413E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2010)/Bmsy	6.394E-01	----	----
F./Fmsy	Ratio: F(2009)/Fmsy	1.138E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2009)	8.787E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2010	1.632E+05	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	6.394E-01	----	----
Ye.	Equilibrium yield available in 2010	2.221E+05	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)

...as proportion of MSY 8.700E-01 ---- ----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------

fmsy(1)	Series 1	4.779E+03	Fmsy/q(1)	Fmsy/q(1)
fmsy(2)	Series 2	6.440E+04	Fmsy/q(2)	Fmsy/q(2)

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1994	1.152	9.538E+04	9.436E+04	1.087E+05	1.087E+05	1.067E+05	1.796E+00	2.396E-01
2	1995	0.984	9.339E+04	1.003E+05	9.868E+04	9.868E+04	1.124E+05	1.535E+00	2.346E-01
3	1996	0.926	1.071E+05	1.169E+05	1.083E+05	1.083E+05	1.279E+05	1.445E+00	2.691E-01
4	1997	0.848	1.267E+05	1.412E+05	1.198E+05	1.198E+05	1.489E+05	1.323E+00	3.182E-01
5	1998	0.758	1.557E+05	1.770E+05	1.341E+05	1.341E+05	1.763E+05	1.182E+00	3.913E-01
6	1999	0.834	1.979E+05	2.099E+05	1.750E+05	1.750E+05	1.982E+05	1.300E+00	4.972E-01
7	2000	0.896	2.210E+05	2.241E+05	2.007E+05	2.007E+05	2.065E+05	1.397E+00	5.554E-01
8	2001	1.003	2.268E+05	2.184E+05	2.190E+05	2.190E+05	2.032E+05	1.564E+00	5.699E-01
9	2002	0.991	2.111E+05	2.066E+05	2.046E+05	2.046E+05	1.962E+05	1.544E+00	5.303E-01
10	2003	0.959	2.026E+05	2.024E+05	1.940E+05	1.940E+05	1.936E+05	1.495E+00	5.091E-01
11	2004	0.916	2.022E+05	2.059E+05	1.887E+05	1.887E+05	1.958E+05	1.429E+00	5.080E-01
12	2005	0.935	2.093E+05	2.103E+05	1.966E+05	1.966E+05	1.985E+05	1.458E+00	5.258E-01
13	2006	0.906	2.112E+05	2.146E+05	1.945E+05	1.945E+05	2.011E+05	1.413E+00	5.306E-01
14	2007	1.003	2.177E+05	2.109E+05	2.116E+05	2.116E+05	1.988E+05	1.564E+00	5.470E-01
15	2008	0.903	2.049E+05	2.096E+05	1.892E+05	1.892E+05	1.980E+05	1.408E+00	5.149E-01
16	2009	0.730	2.138E+05	2.348E+05	1.714E+05	1.714E+05	2.121E+05	1.138E+00	5.371E-01
17	2010		2.545E+05				6.394E-01		

Data type CE: Effort-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1994	2.024E+01	1.266E+01	0.4136	3.903E+04	3.903E+04	-0.46908	1.000E+00
2	1995	1.216E+01	1.346E+01	0.2729	2.736E+04	2.736E+04	0.10136	1.000E+00
3	1996	1.450E+01	1.569E+01	0.2878	3.364E+04	3.364E+04	0.07872	1.000E+00
4	1997	1.624E+01	1.896E+01	0.2458	3.472E+04	3.472E+04	0.15436	1.000E+00
5	1998	1.146E+01	2.375E+01	0.1700	3.009E+04	3.009E+04	0.72888	1.000E+00
6	1999	1.351E+01	2.817E+01	0.1580	3.316E+04	3.316E+04	0.73460	1.000E+00
7	2000	1.957E+01	3.007E+01	0.2056	4.606E+04	4.606E+04	0.42978	1.000E+00
8	2001	3.138E+01	2.931E+01	0.2201	4.807E+04	4.807E+04	-0.06811	1.000E+00
9	2002	3.492E+01	2.773E+01	0.1984	4.099E+04	4.099E+04	-0.23062	1.000E+00
10	2003	3.524E+01	2.717E+01	0.2521	5.103E+04	5.103E+04	-0.26024	1.000E+00
11	2004	2.894E+01	2.764E+01	0.2236	4.605E+04	4.605E+04	-0.04621	1.000E+00
12	2005	3.522E+01	2.822E+01	0.2470	5.195E+04	5.195E+04	-0.22154	1.000E+00
13	2006	3.530E+01	2.880E+01	0.2680	5.751E+04	5.751E+04	-0.20350	1.000E+00
14	2007	3.931E+01	2.831E+01	0.2889	6.094E+04	6.094E+04	-0.32852	1.000E+00
15	2008	3.753E+01	2.813E+01	0.2549	5.341E+04	5.341E+04	-0.28858	1.000E+00
16	2009	3.478E+01	3.151E+01	0.2146	5.040E+04	5.040E+04	-0.09865	1.000E+00

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) Series 2

Data type CE: Effort-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1994	8.887E-01	9.397E-01	0.7381	6.965E+04	6.965E+04	0.05586	1.000E+00
2	1995	9.480E-01	9.985E-01	0.7114	7.133E+04	7.133E+04	0.05192	1.000E+00
3	1996	1.006E+00	1.164E+00	0.6387	7.466E+04	7.466E+04	0.14577	1.000E+00

4	1997	1.163E+00	1.407E+00	0.6026	8.511E+04	8.511E+04	0.18979	1.000E+00
5	1998	1.464E+00	1.763E+00	0.5879	1.041E+05	1.041E+05	0.18539	1.000E+00
6	1999	1.997E+00	2.090E+00	0.6759	1.419E+05	1.419E+05	0.04595	1.000E+00
7	2000	2.209E+00	2.232E+00	0.6901	1.547E+05	1.547E+05	0.01030	1.000E+00
8	2001	2.517E+00	2.175E+00	0.7827	1.710E+05	1.710E+05	-0.14593	1.000E+00
9	2002	2.447E+00	2.057E+00	0.7921	1.636E+05	1.636E+05	-0.17335	1.000E+00
10	2003	2.172E+00	2.016E+00	0.7066	1.430E+05	1.430E+05	-0.07479	1.000E+00
11	2004	2.202E+00	2.051E+00	0.6929	1.427E+05	1.427E+05	-0.07123	1.000E+00
12	2005	2.269E+00	2.094E+00	0.6878	1.446E+05	1.446E+05	-0.08012	1.000E+00
13	2006	2.156E+00	2.137E+00	0.6383	1.370E+05	1.370E+05	-0.00849	1.000E+00
14	2007	2.406E+00	2.100E+00	0.7144	1.507E+05	1.507E+05	-0.13574	1.000E+00
15	2008	2.200E+00	2.087E+00	0.6480	1.358E+05	1.358E+05	-0.05271	1.000E+00
16	2009	2.184E+00	2.338E+00	0.5153	1.210E+05	1.210E+05	0.06841	1.000E+00

Fmsy	Fishing mortality rate at MSY	0.613
B./Bmsy	Ratio: B(2010)/Bmsy	0.639
F./Fmsy	Ratio: F(2009)/Fmsy	1.138

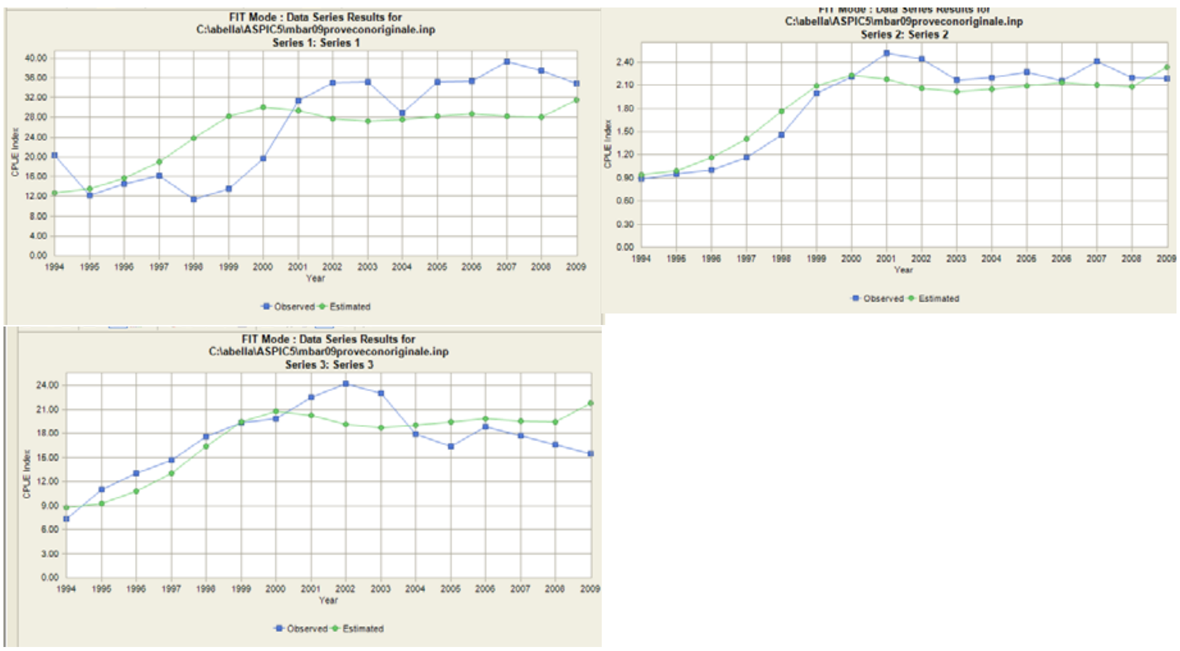


Fig. 5.21.4.1.3.1 Fitting of the 3 time series (S1=Porto Santo Stefano, S2=Viareggio, S3 Medits abundance index).

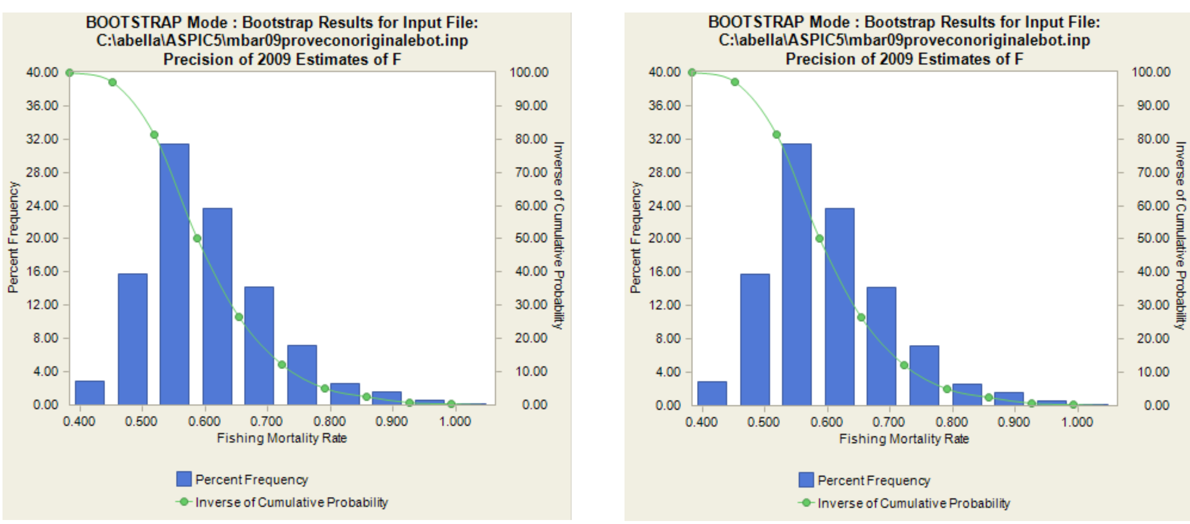


Fig. 5.21.4.1.3.2 Precision of estimated value of F (left) and Biomass value for 2009 with ASPIC by Bootstrap.

The results of the Biomass Dynamic Model suggest that the stock, if effort is kept at the current levels or lower, is shifting from an overexploitation towards a more optimal exploitation status with an *F* estimate for the last year not much higher than F_{MSY} level (current F_{curr}/F_{MSY}=1.13), but with the ratio B_{curr}/B_{MSY} still well below 1 (B_{2010}/B_{MSY}=0.64).

Data of abundance index of Porto Santo Stefano have shown a lower correlation with surveys data, probably due to the fact that in this port, the fleet has a lightly different spatial behaviour (they operate at a higher mean depth) and the species is not a prioritary commercial species. A value of F_{MSY} of 0.64 was estimated. It is important to remark, as shown in Fig. 5.21.4.1.3.3, that the level of biomass shows a light increase in the last years while *F* decreased since 2001 except in 2007, and dropped particularly in the last year 2009.

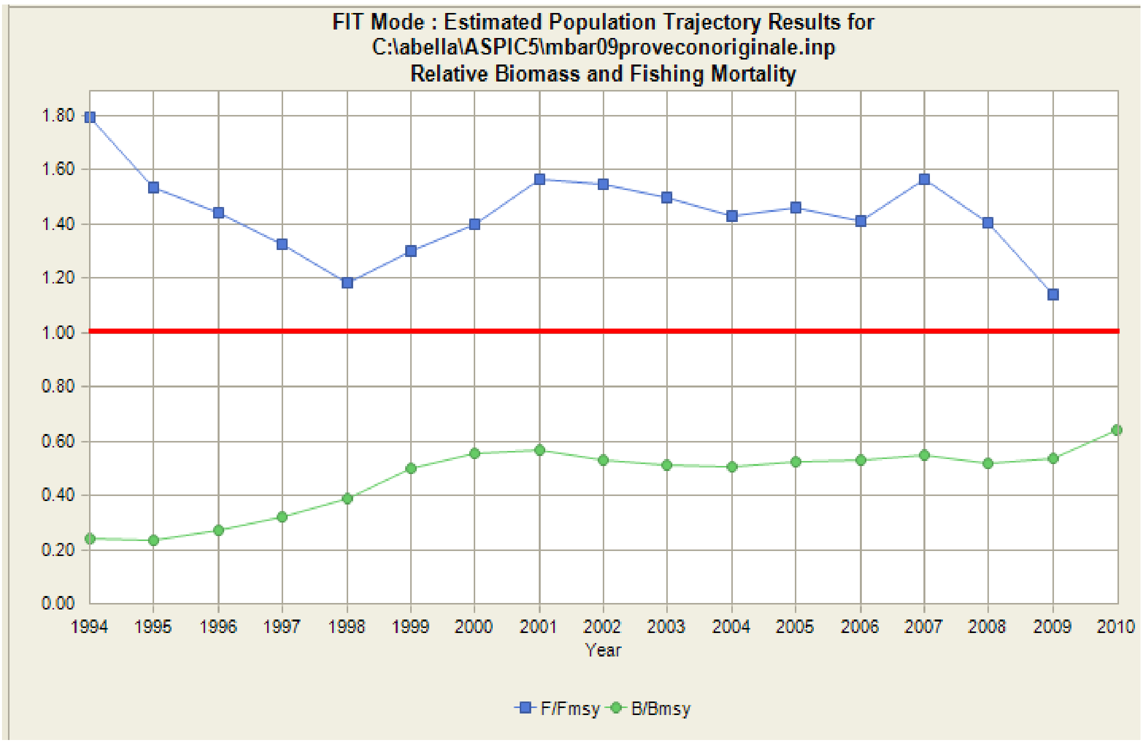


Fig. 5.21.4.1.3.3 Historic trend in estimated fishing mortality as F/F_{MSY} ratio (upper panel) and biomass as B/B_{MSY} ratio (lower panel).

5.21.5. Medium term prediction

5.21.5.1. Justification

An ASPIC forecasting model (ASPIC-P) was run to estimate future 10 years stock parameters under status quo fishing mortality. Projections suggest that a light increase in biomass should occur in the medium term (up to 2020) if *F* is kept at the current rate. The new biomass level that is assumed to be obtained at medium term keeping *F* unchanged is however lower (about 90%) than B_{MSY}, that is the level of biomass assumed to maximize the sustainable yields.

5.21.5.2. Input parameters

See section 5.21.4.1.2.

5.21.5.3.Results

If the estimated value for the current F is kept unchanged, in the medium term the prediction indicates that the biomass may reach the 85% B_{MSY} level.

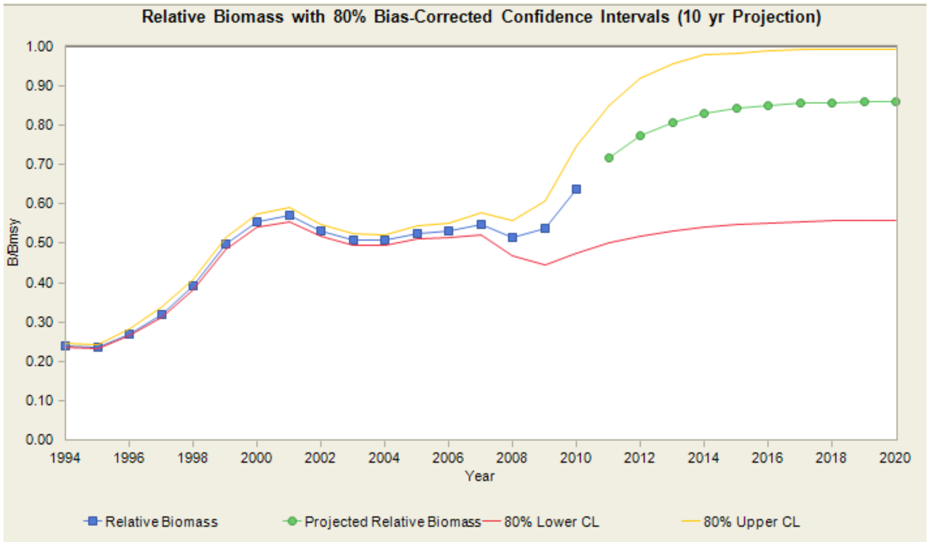


Fig. 5.21.5.3.1 Historic and forecasting of B/Bmsy assuming current estimate of F kept unchanged for the next 10 years with 80% confidence intervals derived from bootstrapping.

In the case F is reduced by 10% biomass may reach B_{MSY}.

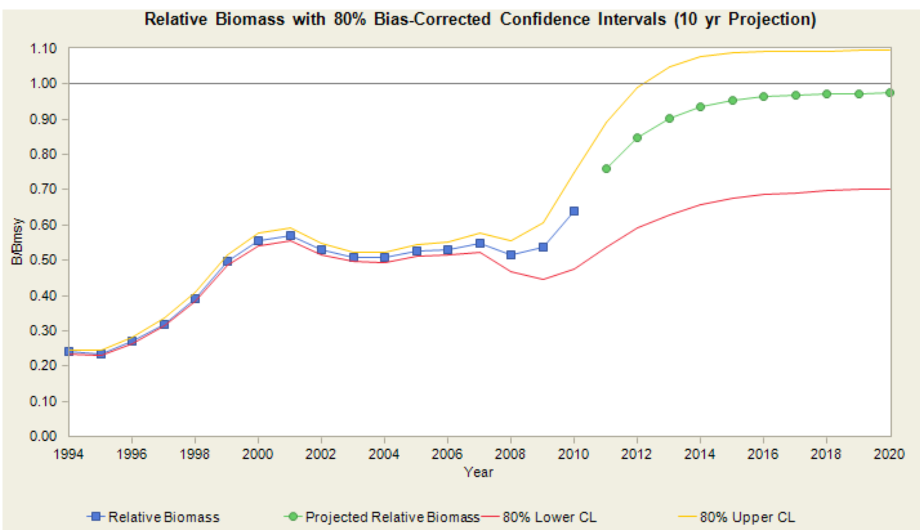


Fig. 5.21.5.3.2 Forecasting for B/BMSY reducing the current level of F by 10% with bootstrapped 80% confidence limits.

5.21.6. Long term prediction

5.21.6.1. Justification

A traditional Beverton & Holt Y/R analysis was performed with the “Yield” software. The used model does not allow vectorial values of *M* and hence, in alternative, a weighted average value was used as input. The approach also assumes an asymptotic behavior of catchability over the size of first capture, hypothesis that is likely for the species in question. All the analyses were performed as a per-recruit basis, assuming recruitment constant with only a random fluctuation.

5.21.6.2. Input parameters

We used the growth and L/W parameters defined in Table 5.21.1.2.1. A weighted mean value of M of 0.8 was used instead of an M-at-size vector.

5.21.6.3. Results

Values of F_{max} =0.63 and $F_{0.1}$ =0.49 were estimated and the F rate at which the spawning biomass is expected to be reduced to 30% of the pristine Biomass (F30%SSB) was estimated as 0.24. Relative per recruit estimated values of Y, SSB, Fished Biomass and Total Biomass are shown in Fig 5.21.6.3.1.

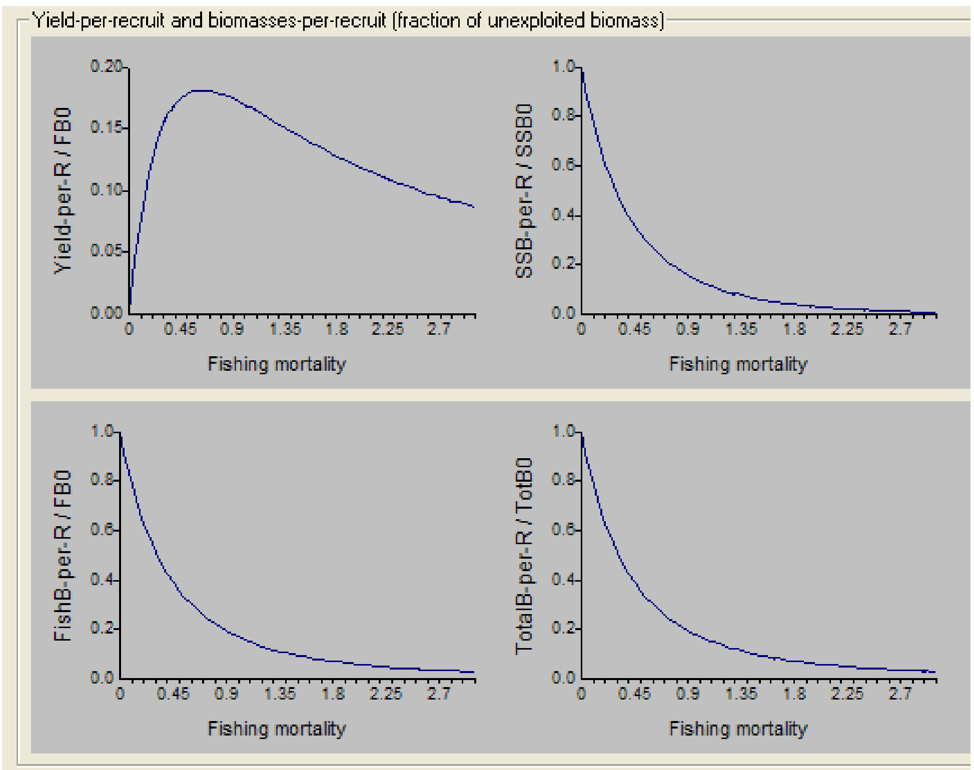


Fig. 5.21.6.3.1. Results of the Y/R analysis.

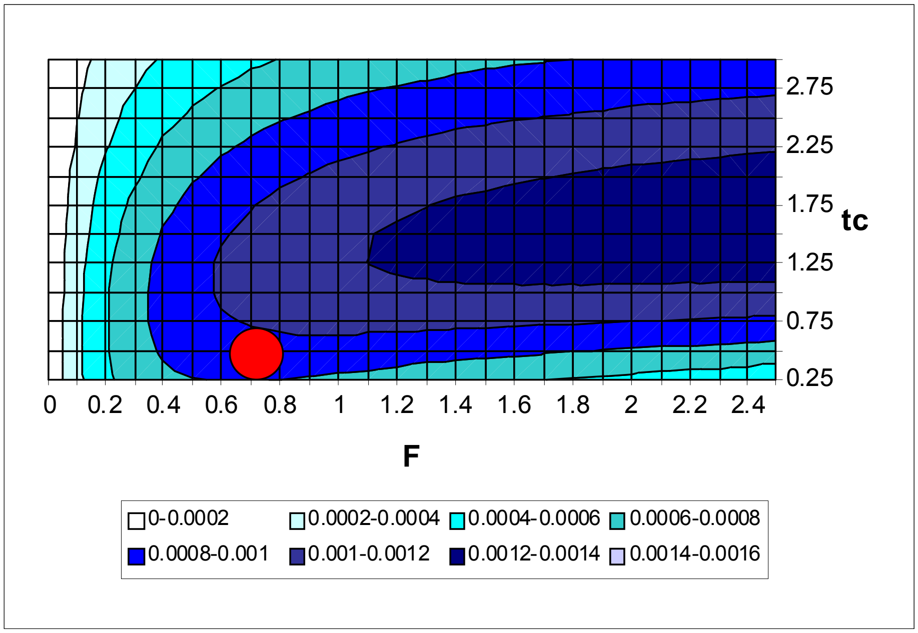


Fig. 5.21.6.3.2. Yield-per-Recruit isoplets. The red circle represents the current combination of F and tc.

5.21.7. Data quality

The available data from both fisheries dependent and fisheries independent sources available is considered good enough in order to perform a reliable assessment of the stock. However, the species dynamics (fast growth, presence of a reduced number of cohorts, the lacking of a good knowledge on the relationship stock/recruitment, the difficulties of ageing, the lacking of a long time series of data on demographic structure of the commercial catches) make difficult the use of most of the age-based traditional approaches of stock assessment.

The issue of unit stocks definition inside the GSA 09 still remains unsolved. In fact, the GSA 09 is divided in two portions, separated by the geographic barrier represented by the Elba island, with the northern portion located in the Ligurian Sea, and the southern one in the Tyrrhenian sea. Considering the sedentary behaviour of the species, that only shows ontogenetic migrations from the shore towards deeper waters, it is likely that the status of the stock in relatively small areas along the coast, will mainly depend on the fishing pressure exerted on them by the local fleets, and will not be influenced by what happens in neighboring areas, exploited at different rates by other fleets. The pooling of the data coming from heterogeneous sub-areas characterized by different levels of abundance and demographic structure, can lead to uncertainty in the definition of the status of the stocks, and such merging may produce a wrong perception of the real status of the stocks and advice, and may lead to a worse utilization of the potential productivity of the resources.

Landings from 2009 were not submitted by the Italian authorities.

5.21.8. Scientific advice

5.21.8.1. Short term considerations

5.21.8.1.1. State of the spawning stock size

The index of stock abundance from GRUND survey shows high variability throughout the time series, but no trend is observed. The index of abundance from MEDITS surveys, which approximates a spawning stock biomass index (i.e. mostly mature fish), does not show any trend from 1994 to 2009. Wide fluctuations are observed.

5.21.8.1.2. State of recruitment

Recruitment has slightly increased, especially in the most recent years.

5.21.8.1.3. State of exploitation

SGMED proposes F_{MSY}=0.64 as limit management reference point for exploitation consistent with high long term yields. The estimate of the current fishing mortality F_{2009} of 0.73 (derived from ASPIC) is higher than the value considered as limit reference point (F_{MSY}=0.64) and the value derived from the yield-per-recruit analysis ($F_{0.1}$ =0.49). SGMED classifies the stock of red mullet in GSA 09 as subject to overfishing. SGMED recommends to reduce fishing effort of all fleets by about 12% to reach the management reference point. The size of first capture is too low and an increase in yield can be expected in the case of a reduction of fishing effort and through the use of more selective gears. It is advisable to avoid illegal fishing within the 3 miles as well as the landing of undersized individuals in order to reduce fishing pressure on juveniles.

5.22. Stock assessment of red mullet in GSA 10

5.22.1. Stock identification and biological features

5.22.1.1. Stock Identification

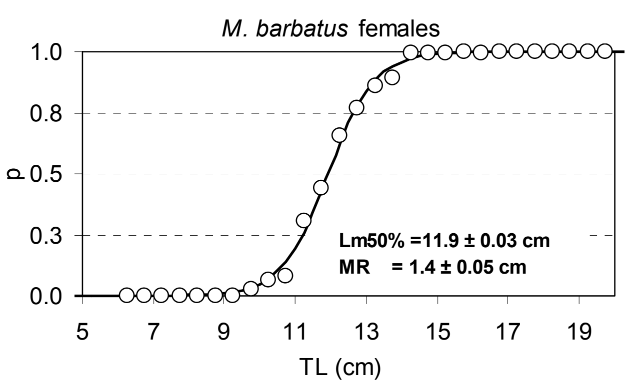
Red mullet stock was assumed in the boundaries of the whole GSA 10, lacking specific information on stock identification. *M. barbatus* is with European hake and deep-water rose shrimp a key species of the fishing assemblages in the central-southern Tyrrhenian Sea (GSA 10). The species is almost exclusively distributed on the continental shelf and is a rather small-sized, fast-growing and characterized by a relatively short lifespan. It spawns in late spring-early summer with a peak in June-July. In late summer, recently settled juveniles are highly concentrated nearshore and this concentration is still present until October. Aggregation of juveniles and subsequent movements towards more offshore grounds have been reported and indicated as a source of increased vulnerability of this population component to harvest (Voliani et al., 1998). During late summer-early autumn (September-October), the species is intensely fished. About three-four months after settlement, red mullet has spread up to depths of about 100 m.

5.22.1.2. Growth

The growth of red mullet has been studied in the GSA 10 using two different approaches that allowed the validation of the aging: 1) whole otolith readings and 2) the analysis of length-frequency distributions using techniques as Batthacharya for separation of modal components. The estimates of the von Bertalanffy growth parameters by sex for the period 2006-2008 were: females L_∞=27 cm k=0.363 t_0= -0.6; males: L_∞=21 cm k=0.534 t_0= -0.5; sex combined L_∞=26 cm k=0.42 t_0= -0.4. Parameters of the length-weight relationship were a=0.0105; b=3.0207 for females, a=0.0103; b=3.0231 for males and a=0.0103; b=3.0246 for sex combined.

5.22.1.3. Maturity

According to the data obtained in the DCF, the proportion of mature females (fish belonging to the maturity stage 2b onwards macroscopically classified using a 8 stage scale (Medits-Handbook_2007.v5) by length class in the period 2006-2008 is reported in the table below together with the estimated maturity ogives which indicates a $L_{m50\%}$ of about 12 cm (±0.03 cm) (Fig. 5.22.1.3.1).



TL (cm)	Proportion of mature females
9	0.017
10	0.075
11	0.38
12	0.71
13	0.88
14	0.99
15	0.99
16	0.99
17	1
18	1
19	1
20	1

Fig. 5.22.1.3.1 Maturity ogives and proportions of mature female of red mullet in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio was in favour of males up to the size of about 11 cm and females start to prevail for large individuals (Fig. 5.22.1.3.2).

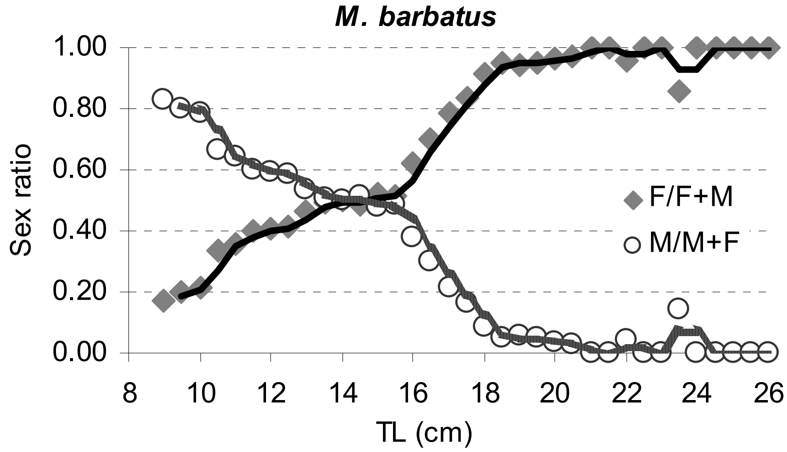


Fig. 5.22.1.3.2 Sex ratio for females and males by length.

5.22.2. Fisheries

5.22.2.1. General description of fisheries

Red mullet is an important species in the area, targeted by trawlers and small scale fisheries using mainly gillnet and trammel nets. Fishing grounds are located along the coasts of the whole GSA, offshore around 50 m depth or 3 miles from the coast.

5.22.2.2. Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures as closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of the fleet, the Italian fishing licenses have been fixed since the late eighties. After 2000, in agreement with the European Common Policy of Fisheries, a gradual decreasing of the fleet capacity is implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990. Two closed areas were also established in 2004 along the mainland, in front of Sorrento peninsula (Napoli Gulf) and Amantea (Calabrian coasts) although these protected area mainly cover the distribution of coastal species. Other measures on which the management regulations are based regard technical measures (mesh size) and minimum landing sizes (EC 1967/06). In the GSA 10 the fishing ban has historically not been mandatory, and it was adopted on a voluntary basis. However, in the last years it has been mandatory. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

5.22.2.3. Catches

5.22.2.3.1. Landings

Available landing data collected under the DCF framework ranged from 524 tons in 2004 to 314 tons in 2008, the latter being the lowest value registered (Tab. 5.22.2.3.1.1). Most part of the landings of red mullet were from trawlers up to 2006 (Fig. 5.22.2.3.1.1), while since 2007 the level of catches of trawlers is similar to that of the other métier grouped together, to which the maximum contribution is given by gillnet (GNS) and trammel net (GTR). In 2008 the catches of both métier are decreasing.

Tab. 5.22.2.3.1.1 Annual landings by major fishing techniques in tons for red mullet in the GSA 10 (2004-2008).

Somma di LW			FT_LVL4								
SPECIES	AREA	YEAR	miscellanea	GND	GNS	GTR	LLS	OTB	PS	SB-SV	Total
MUT	10	2004	9.801		15.772	96.044	0.58	400.366	0.037	1.773	524.373
		2005	13.533	0.02	24.873	102.202	25.771	254.975			421.374
		2006	0.553		34.51	68.246		289.704			393.013
		2007			24.433	212.208		265.23			501.871
		2008	0.091	0.043	7.185	125.371		182.268			314.958

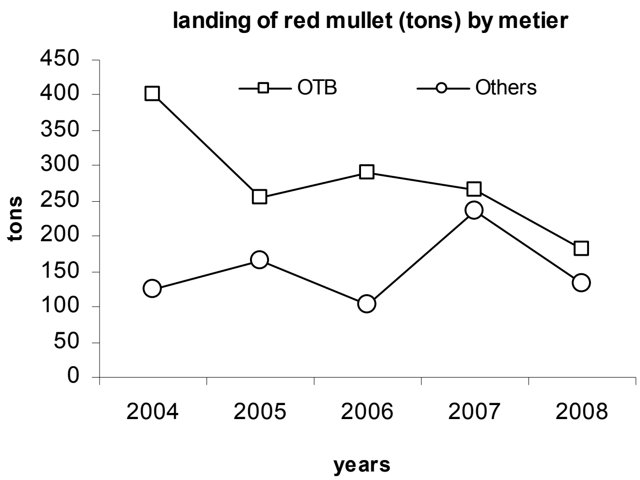


Fig. 5.22.2.3.1.1 Annual landings by major fishing techniques (OTB and all the other grouped together) in tons for red mullet in the GSA10.

5.22.2.3.2. Discards

The proportion of the discards of red mullet in the GSA 10 was generally low and concentrated in the third and fourth quarter, when recruitment is occurring. In 2006 the estimate of discard proportion compared to the total landings in the GSA was about 2% in weight. Despite this value was lower than the prescription of reg UE 1639/2001 (10% in weight or 20% in number), the composition in length and age was estimated, showing the dominance of the age 0 group with an the average length of 8.7 cm. In 2006, 8 t of discards were reported.

5.22.2.3.3. Fishing effort

The trends in fishing effort by year and major gear type in terms of kWdays are listed in Tab. 5.22.2.3.3.1.

Tab. 5.22.2.3.3.1 Trend in fishing effort (kW*days) for GSA 10 by gear type, 2004-2008 as reported through the DCF official data call.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
10	ITA				VL0006				1347			
10	ITA				VL0612		84318	65385	32480	27509	24608	
10	ITA				VL1218		13612	27229	5986	18865	7513	
10	ITA	DRB	MOL		VL1218		10149	14848	23073	34394	21067	
10	ITA	FPO	DEMSP		VL0006				5938			
10	ITA	FPO	DEMSP		VL0612			14239				
10	ITA	GND	SPF		VL0006					1521	1437	
10	ITA	GND	SPF		VL0612			4316	8070		15882	
10	ITA	GND	SPF		VL1218		1895	3429			8303	
10	ITA	GNS	DEMSP		VL0006				221	9122	6623	
10	ITA	GNS	DEMSP		VL0612		45875	229661	74360	139622	124448	
10	ITA	GNS	DEMSP		VL1218						18180	
10	ITA	GTR	DEMSP		VL0006				30332	16894	13248	
10	ITA	GTR	DEMSP		VL0612		86781	82711	191382	140832	172542	
10	ITA	GTR	DEMSP		VL1218		12514	21108	28430	16110	17755	
10	ITA	LHP-LHM	CEP		VL0006				2369	3463	1018	
10	ITA	LHP-LHM	CEP		VL0612		1239	2450	4458	15003		
10	ITA	LHP-LHM	FINF		VL1218		716	1013				
10	ITA	LLD	LPF		VL0006						1968	
10	ITA	LLD	LPF		VL0612						2138	
10	ITA	LLD	LPF		VL1218		4627		10673	10266	14174	
10	ITA	LLS	DEMF		VL0006				11628	3467	2996	
10	ITA	LLS	DEMF		VL0612		104125	101629	61456	56957	26693	
10	ITA	LLS	DEMF		VL1218		13376	27517	61348	52670	32330	
10	ITA	OTB	DEMSP		VL0612		16454					
10	ITA	OTB	DEMSP		VL1218		44743		102448	127832	98014	
10	ITA	OTB	DEMSP		VL1824		90104		224283	204068	242063	
10	ITA	OTB	DWSP		VL1824						2388	
10	ITA	OTB	MDDWSP		VL1218		130612	247796	142430	169560	83026	
10	ITA	OTB	MDDWSP		VL1824		97221	239878	71963	86844	55526	
10	ITA	PS	LPF		VL0612					5291		
10	ITA	PS	LPF		VL1218					4926		
10	ITA	PS	SPF		VL0006				7337			
10	ITA	PS	SPF		VL0612		4653	27986				
10	ITA	PS	SPF		VL1218		49995	54113	68805	73452	20179	
10	ITA	SB-SV	DEMSP		VL0006				0			
10	ITA	SB-SV	DEMSP		VL0612		12786					
10	ITA	SB-SV	DEMSP		VL1218						8756	

5.22.3. Scientific surveys

5.22.3.1. Medits

5.22.3.1.1. Methods

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were carried out yearly (May-July), applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. Abundance data (number of fish per surface unit) were standardised to square kilometre, using the swept area method.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls were reported per depth stratum (Tab. 5.22.3.1.1.1).

Tab. 5.22.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	9	10	10	10	10	10	10	10	9	9	9	9	9	9	9	9
GSA10_050-100	12	12	12	12	12	12	12	12	10	10	10	10	10	10	10	10
GSA10_100-200	20	20	20	20	20	20	20	20	17	17	17	17	17	17	17	17
GSA10_200-500	26	27	26	26	27	26	26	28	22	22	22	22	22	22	22	22
GSA10_500-800	31	30	31	31	31	30	31	29	26	27	26	26	26	26	26	26

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.22.3.1.2. Geographical distribution patterns

Map of the bubble plot of the survey indices indicates a higher abundance of the population in the southernmost part of the area, along the mainland and the north Sicily coasts. The approach based on spatial indicators (Woillez *et al*., 2007) to characterise the spatial dynamics of red mullet life stages has been applied to the GSA 10 (Spedicato *et al*., 2007), with the objectives of identifying areas where red mullet recruits are more concentrated (Fig. 5.22.3.1.2.1), establishing relationships with the adult distribution and detecting the ability of spatial indicators to capture the stability of the spatial occupation of preferential sites across the years. The spatial indices mainly studied were the centre of gravity (CG), the inertia (I) and the global index of collocation (GIC). Gravity centres (xcg-longitude; ycg-latitude; graph below) by age groups across years and life-stages highlighted a less changing spatial location of the younger age (A1) compared to the older ones (A2 and A3) that were more dispersed. The approach of the spatial indicators enabled the location of the geographical zone (along the Calabrian coast, southwards in the study area) where recruits (age 0 fish) of red mullet are mainly distributed and to verify that these locations are rather stable across years.

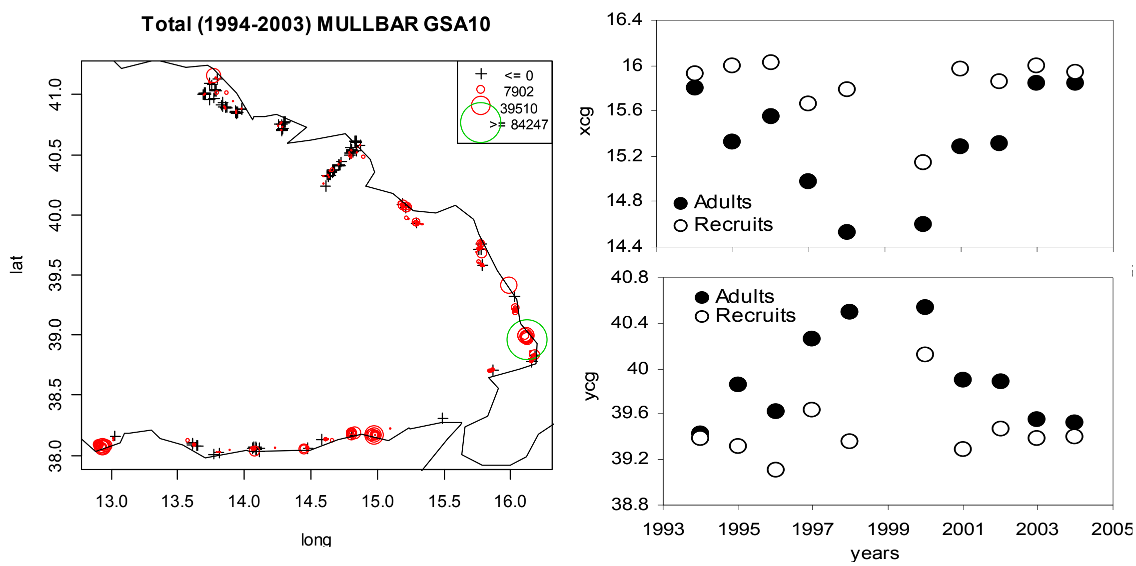


Fig. 5.22.3.1.2.1 Scaled survey catches of red mullet in GSA 10 and centre of gravity (CG) of recruits and adults.

5.22.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 10 was derived from the international survey MEDITS. Figure 5.22.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 10. Abundance indices from MEDITS trawl-survey show a very variable pattern also due to the presence of recruits in some years. However, an increasing pattern was observed from 1999 to 2002, a decreasing pattern from 2000 to 2006 and again an increasing in 2007, followed by a sharp reduction in 2008 and a new remarkable rising in 2009. Biomass indices followed a similar pattern except for the last value that was low (Fig. 5.22.3.1.3.1).

The re-estimated abundance and biomass indices do reveal identical trends (Figure 5.22.3.1.3.2) to those shown above. However, the recent abundance and biomass indices in 2007 appear high but are subject to high uncertainty.

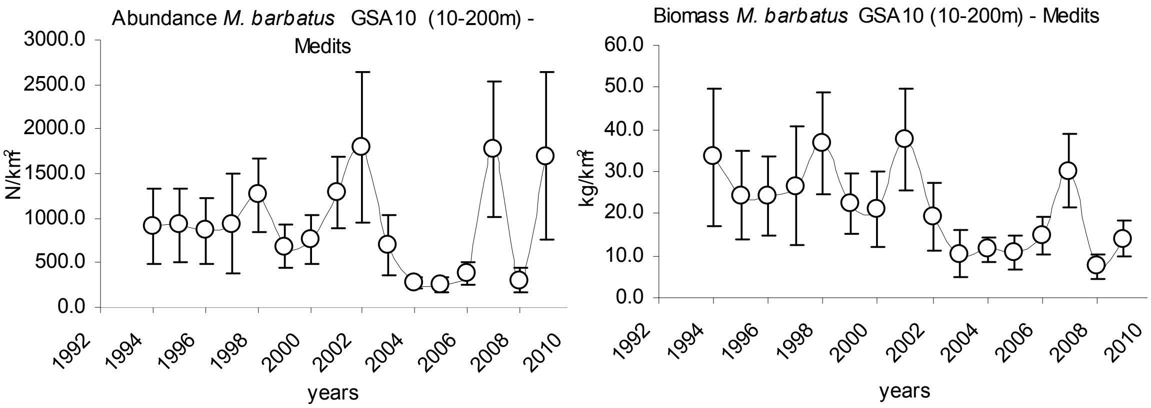


Fig. 5.22.3.1.3.1 Trends in survey abundance and biomass derived from MEDITS.

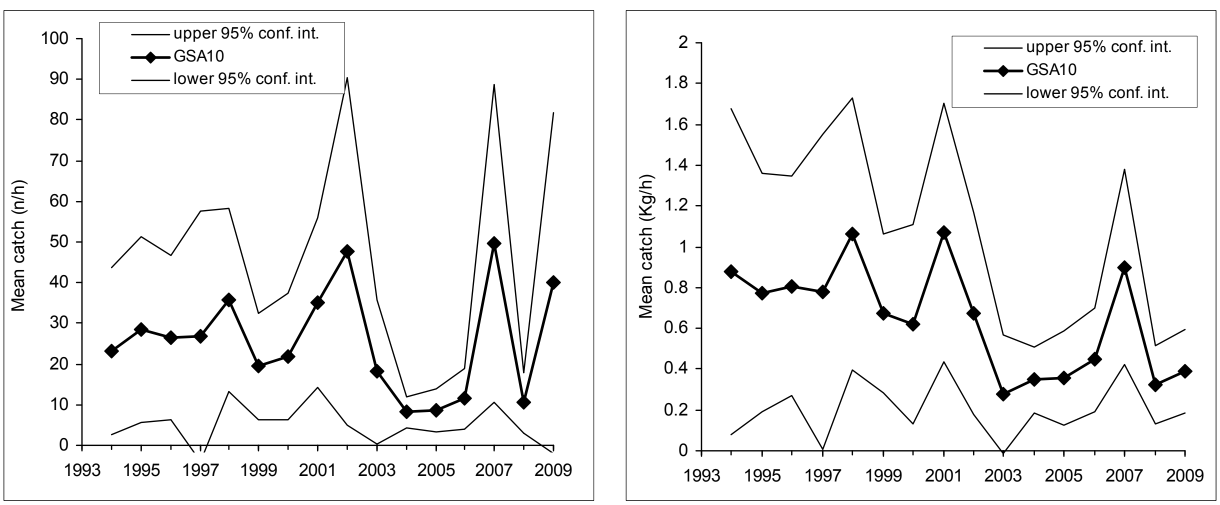


Fig. 5.22.3.1.3.2 Abundance and biomass indices of red mullet in GSA 10 derived from MEDITS.

5.22.3.1.4. Trends in abundance by length or age

No trend in the mean length was observed in MEDITS survey.

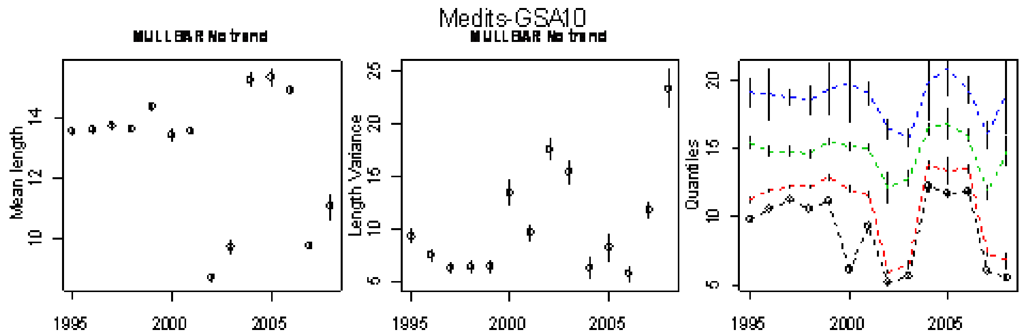


Fig. 5.22.3.1.4.1 Mean length, variance and quantiles derived from the MEDITS length compositions.

Fig. 5.22.3.1.4.2 and 3 display the stratified abundance indices of GSA 10 in 1994-2001 and 2002-2009.

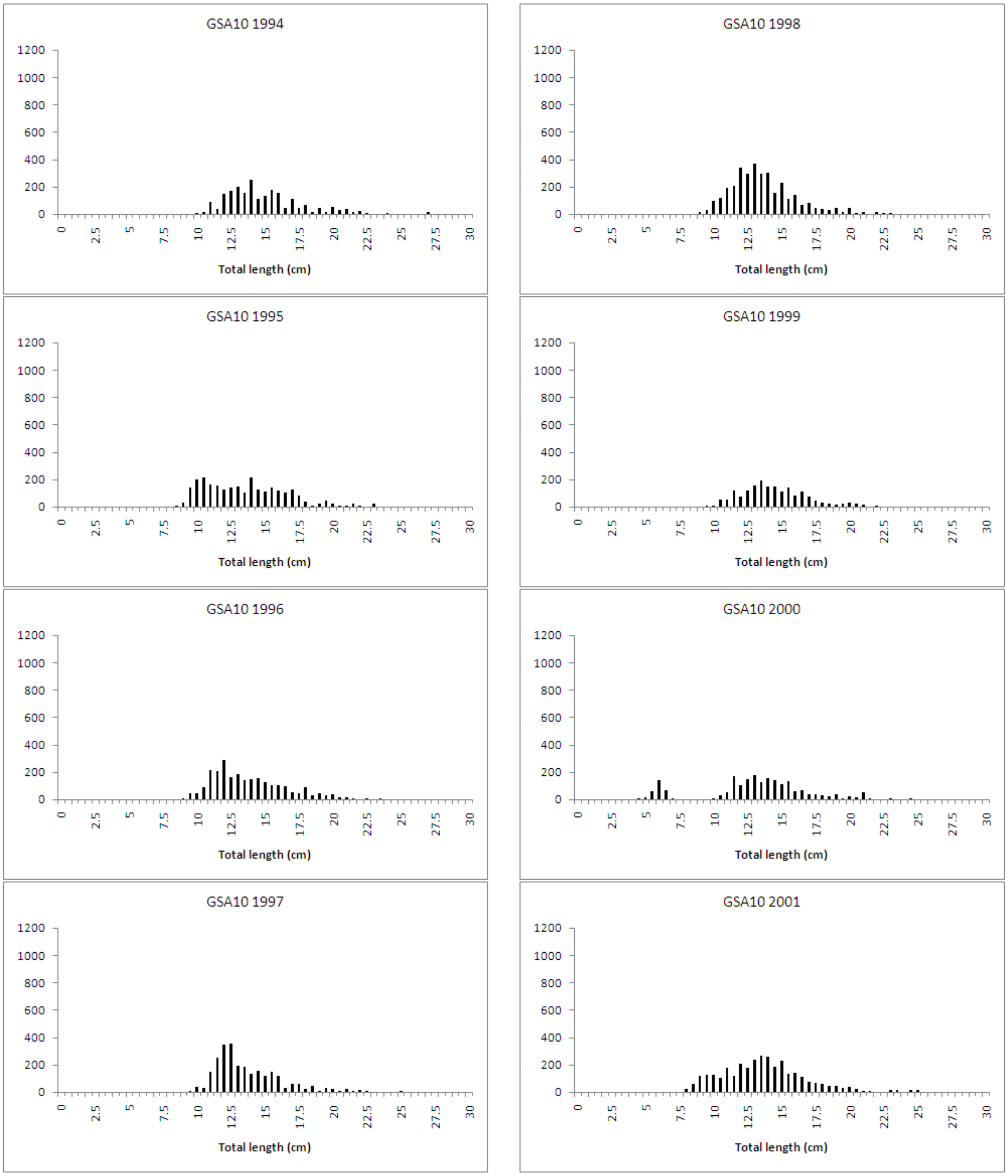


Fig. 5.22.3.1.4.2 Stratified abundance indices by size, 1994-2001.

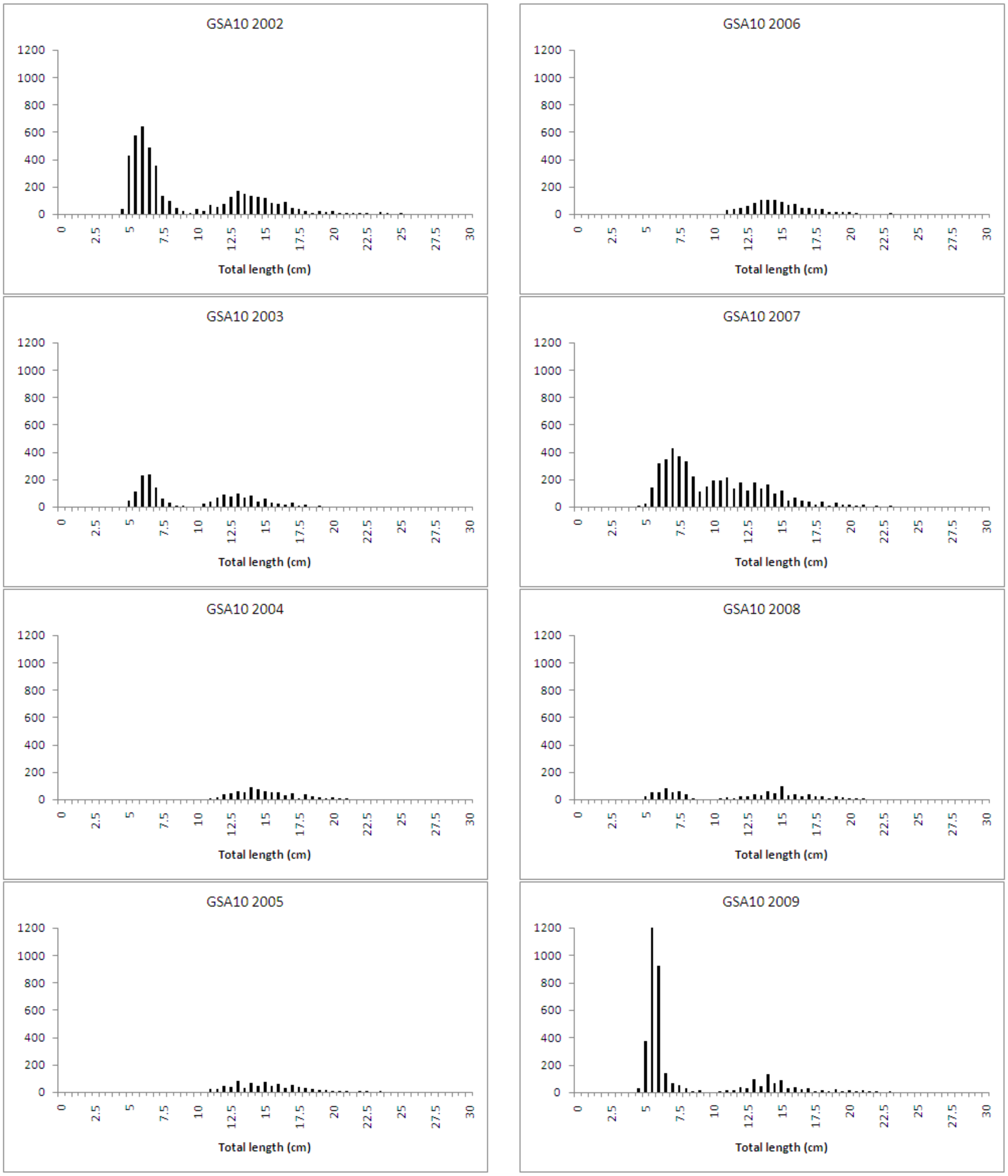


Fig. 5.22.3.1.4.3 Stratified abundance indices by size, 2002-2009.

5.22.3.2. GRUND

5.22.3.2.1. Methods

Since 2003 GRUND surveys (Relini, 2000) was conducted using the same sampler (vessel and gear) in the whole GSA. Sampling scheme, stratification and protocols were similar as in MEDITS. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometer, using the swept area method.

5.22.3.2.2. Geographical distribution patterns

Map of abundance of recruits (n·km^{-2}) as estimated using GRUND data and the ordinary kriging shows that the sub-zones where the recruits are mainly concentrated along the nearshore grounds of the southernmost part of the GSA, except a nucleus located in the northernmost side (Fig. 5.22.3.2.2.1). The higher values were around 25000 recruits·km^{-2}. On average, considering the analyzed distributions (years 1994-2005), the recruits are individual smaller than 11.5 cm (±1.08). These individual are mostly belonging to the age 0 group.

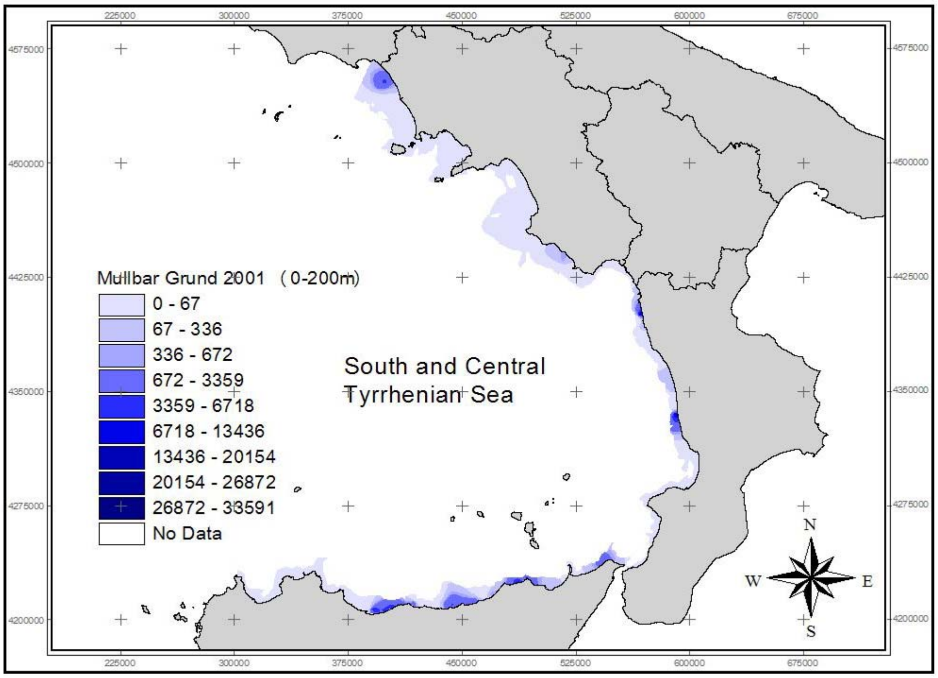
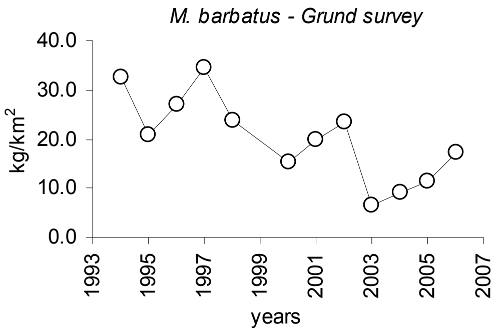
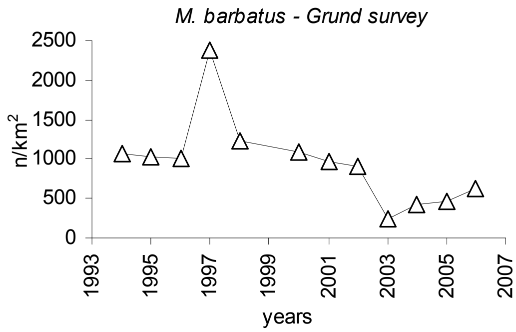


Fig. 5.22.3.2.2.1 Map of abundance of recruits (n·km^{-2}) as estimated using GRUND data and the ordinary kriging.

5.22.3.2.3. Trends in abundance and biomass

Similar to MEDITS trends are derived from the GRUND survey and shown in Fig. 5.22.3.2.3.1. Biomass and abundance indices were both decreasing, while the recruitment indices were highly variable but without any significant trend. Low levels were however observed in the periods 1994-1996 and 2003-2008.





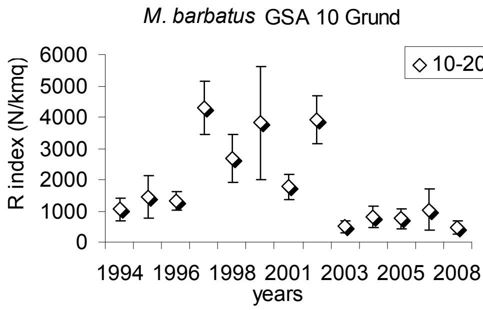


Fig. 5.22.3.2.3.1. Abundance and biomass indices of red mullet in GSA 10 derived from GRUND survey. Also recruitment indices ($n \cdot km^{-2}$) with standard deviation are reported.

5.22.3.2.4. Trends in abundance by length or age

No analyses presented during SGMED-10-02.

5.22.3.2.5. Trends in growth

The occurrence of growth change along time was not fully explored during SGMED-10-02.

5.22.3.2.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.22.4. Assessment of historic stock parameters

5.22.4.1. Method 1: VIT

5.22.4.1.1. Justification

Three complete years (2006-2008) of length frequency distributions of the landings were available, thus only an approach under steady state (pseudocohort) assumption was applicable to the data. Cohort (VPA equation) and Y/R analyses as implemented in the package VIT4win were used (Lleonart and Salat, 1997). Data of number at age were derived from DCF official data in the GSA 10.

5.22.4.1.2. Input parameters

A sex combined analysis was carried out. Regarding growth parameters the set L_∞=26 cm k=0.42 t_0= -0.4 was re-parameterized to the following equivalent set: L_∞=28 cm k=0.4 t_0= -0.4, given the presence of individuals with length higher than 26 cm. The length-weight relationship parameters were: a=0.0103; b=3.0246. A constant natural mortality M = 0.61 (Alagaraja, 1984) was adopted. This value was close to 0.7 an estimate reported for a very slightly exploited area in the Castellammare Gulf (northern Sicily coasts). The terminal fishing mortality was thus set at: F_{term}= 0.7. No plus groups have been introduced. The setting of the proportion of mature females was 0.16 at age 0, 0.92 at age 1 and 1 at age 2. These values were derived from the proportion at length and the VBGF. The proportion between the trawl fishery and the small scale fishery using nets was set as follows:

	2006	2007	2008
OTB	0.76	0.58	0.56
NETS	0.24	0.42	0.44

5.22.4.1.3. Results

Fishing mortality rates (F) by fishing segments (OTB and Nets), total fishing mortality and total mortality rate Z by age estimated by LCA using VIT are reported in the Fig. 5.22.4.1.3.1 and in the Tab. 5.22.4.1.3.1. The pattern of the fishing mortality by fishing fleet shows a shift from trawler to small scale fishery using nets from 2006 to 2007-2008. As a consequence, the fishing mortality on the younger ages appears decreased whilst that on the older ages increased.

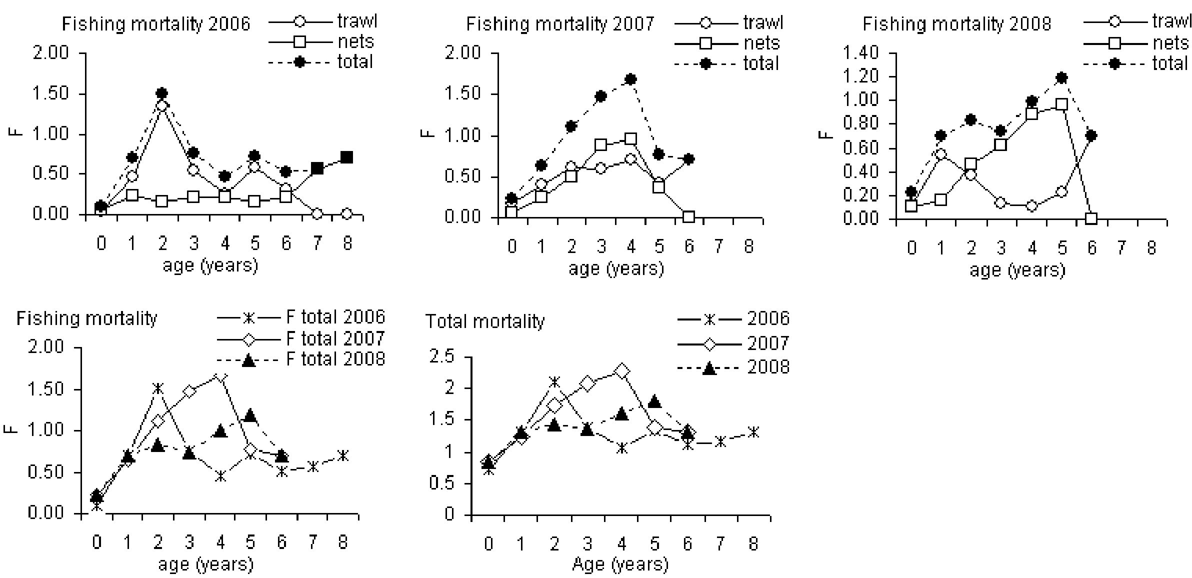


Figure 5.22.4.1.3.1. Fishing (F) by age, fishing metier and year and total mortality (Z) by year.

Tab. 5.22.4.1.3.1. Vectors of fishing mortality by métier, total and year from the LCA performed using VIT.

Fishing mortality

Age	2006 trawl	2006 nets	2006 total	2007 trawl	2007 nets	2007 total	2008 trawl	2008 nets	2008 total
0	0.04	0.06	0.10	0.18	0.05	0.23	0.12	0.11	0.23
1	0.47	0.23	0.70	0.40	0.24	0.64	0.55	0.15	0.70
2	1.34	0.16	1.50	0.62	0.49	1.11	0.37	0.46	0.83
3	0.55	0.21	0.76	0.60	0.87	1.47	0.13	0.62	0.75
4	0.25	0.21	0.46	0.71	0.96	1.67	0.11	0.89	1.00
5	0.58	0.15	0.73	0.42	0.36	0.77	0.22	0.97	1.19
6	0.31	0.21	0.52	0.70	0.00	0.70	0.70	0.00	0.70
7		0.56	0.56						
8		0.70	0.70						

5.22.5. Long term prediction

5.22.5.1. Justification

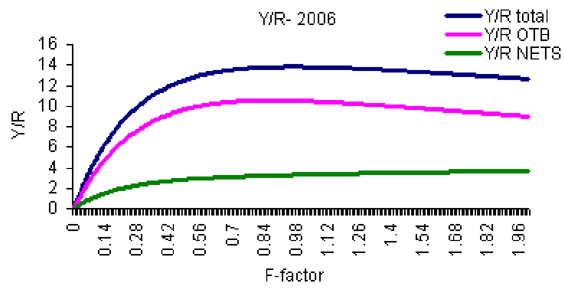
Yield per recruit analysis has been conducted by means of the VIT program.

5.22.5.2. Input parameters

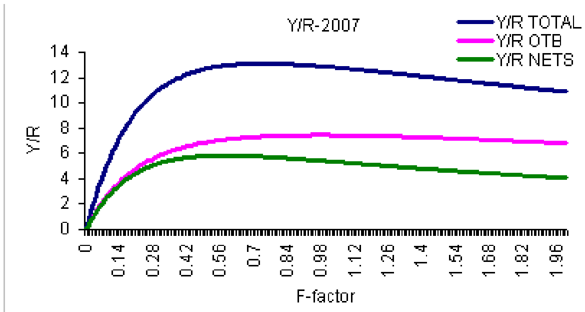
Yield per recruit (Y/R) analysis was performed for each year. Input parameters are the same as used in the VIT program, see previous sections.

5.22.5.3. Results

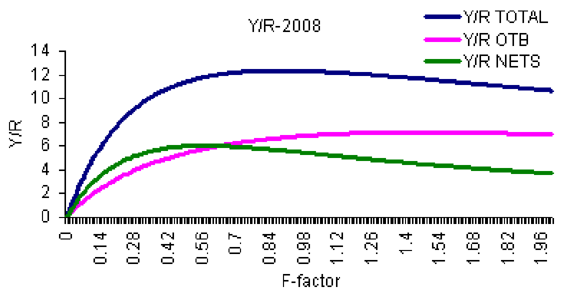
The main results are shown in the Figures 5.22.5.3.1-2. The yield curves were slightly dome-shaped, in particular in 2006. The global current fishing mortality ranges from 0.67 in 2006, 0.94 in 2007 and 0.77 in 2008, while the total mortality was 1.28, 1.55, 1.38 in the three years respectively. The value of $F_{0.1}$ ranged between 0.38 in 2006 to 0.42 in 2008, and was on average 0.4, whilst F_{max} was in the range 0.65-0.70 and on average 0.68.



2006	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0	0	0	74.153	68.734	0	0
F(0.1)	0.57	0.381	13.038	28.978	23.978	10.071	2.966
Fmax	0.97	0.649	13.829	19.99	15.232	10.533	3.296
Fcurr	1.01	0.669	13.825	19.395	14.66	10.507	3.318
Fdouble	2	1.338	12.654	11.653	7.413	8.994	3.659



2007	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0	0	0	70.632	65.213	0	0
F(0.1)	0.43	0.405	12.312	32.309	27.406	6.606	5.706
Fmax	0.74	0.696	13.104	22.945	18.355	7.348	5.756
Fcurr	1.01	0.941	12.856	18.122	13.787	7.456	5.4
Fdouble	2	1.882	10.871	9.929	6.364	6.806	4.065



2008	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0	0	0	70.632	65.213	0	0
F(0.1)	0.54	0.416	11.68	30.779	26.014	5.648	6.032
Fmax	0.89	0.686	12.353	21.411	16.992	6.698	5.656
Fcurr	1.01	0.771	12.306	19.206	14.898	6.892	5.415
Fdouble	2	1.542	10.673	9.861	6.329	6.958	3.716

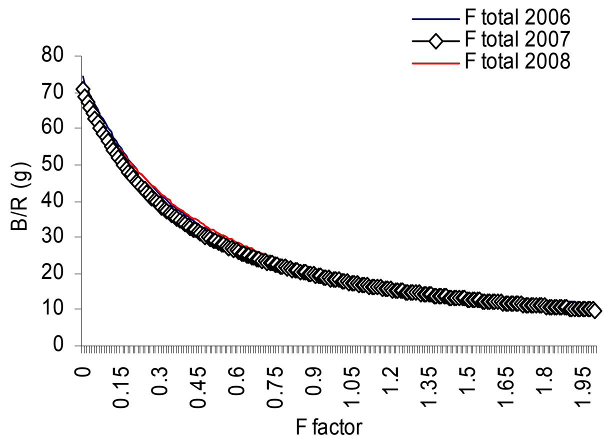
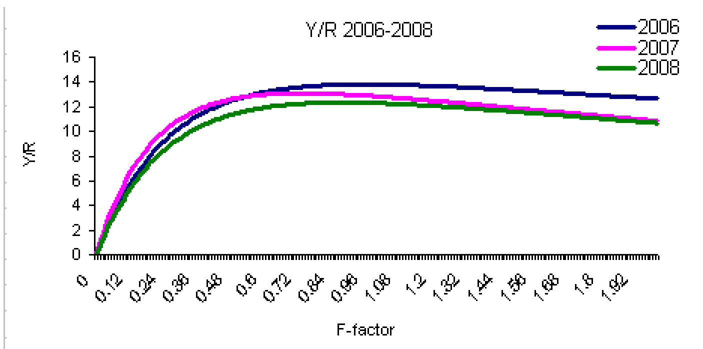


Fig. 5.22.5.3.1 Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported.



Year	F0.1	Y/R (F0.1)	Fmax	Y/R (Fmax)	Fcurr	Y/R (Fcurr)	Fcurr 1-3	Z
2006	0.38	13.04	0.65	13.83	0.67	13.83	0.99	1.28
2007	0.40	12.31	0.70	13.10	0.94	12.86	1.07	1.55
2008	0.42	11.68	0.69	12.35	0.77	12.31	0.76	1.38

Fig. 5.22.5.3.2 Comparison of Y/R curves by year from VIT analysis and summary of the results.

5.22.6. Data quality and availability

Landings from 2009 were not submitted by the Italian authorities. Due to lack of numbers-at-age or numbers-at-length from the landings, the update of the VIT assessment in 2009 was therefore not carried out. Analysis of the effort data were not carried out. All other data available at SGMED-10-02 have been used. The most updated series from trawl survey was up to 2009. A check of the hauls allocation between GSA 09 and 10 is needed before the calculation of indices from the JRC MEDITS database. Data on maturity and growth have also been used. Information from GRUND surveys and studies on nursery in the GSA have also been included.

5.22.7. Scientific advice

5.22.7.1. Short term considerations

5.22.7.1.1. State of the spawning stock size

SGMED is unable to fully evaluate the state of the spawning stock due to the absence of proposed or agreed management reference points. However, survey indices indicate a variable pattern of biomass with the recent values amongst the lowest observed, except for 2007.

5.22.7.1.2. State of recruitment

In 2007 and 2009 the MEDITS surveys indicated abundant recruits.

5.22.7.1.3. State of exploitation

$F_{0.1}$=0.4 is proposed as limit management reference point consistent with high long term yields. Thus, given the results of the present analysis (F 2006=0.67, F 2007=0.94, F 2008=0.77), the stock appeared to have been subject to overfishing during 2006-2008. Assuming status quo in 2009 and given the 2008 situation, a reduction of F of about 40% would be necessary. This advice will be updated at the next SGMED using the data of 2009.

5.23. Stock assessment of red mullet in GSA 11

5.23.1. Stock identification and biological features

5.23.1.1. Stock Identification

Under a management point of view, in the frame of GFCM, it has been decided, when the lack of any evidence does not allow suggesting an alternative hypothesis, that inside each one of the GSAs boundaries inhabits a single, homogeneous stock that behaves as a single well-mixed and self-perpetuating population. Thus, red mullet (*Mullus barbatus*) in GSA 11 was assumed to be confined within the GSA 11 boundaries. In the GSA 11 red mullet is distributed between 0 and 300 m of depth, even though is generally found on shelf bottoms (within 200 m of depths) with the bulk of abundance and biomass up to 100 m. The stock is mainly exploited by the local fishing fleet, using trawl and net gears. Juveniles showed a patchy distribution with some main density hot spots (nurseries) and a high spatio-temporal persistence in western and southern areas.

5.23.1.2. Growth

Analysis of LFDA of red mullet in GSA 11 showed a slow growth pattern both in male and female (SAMED, 2002). For the GSA 11, data from otolith readings (DCR, 2008) show instead a faster growth pattern (sex combined). SGMED-10-02 used the same fast growing parameters adopted in SGMED-09-03. Since the species reaches 50% of its total size at 1.5 year, it has been treated as fast growing.

Table 5.23.1.2.1 Growth parameters for *M. barbatus* in the GSA 11 used in the analyses.

L_∞	29.1
K	0.41
to	-0.39
L/W a	0.01
L/W b	3.02

5.23.1.3. Maturity

The species reaches massively the sexual maturity at the age of one year. Observations of proportion of mature individuals by size and analysis with the standard procedure show that the bulk of the females spawn at a size of about 10 cm. Data on spawning (DCR 2006 and 2007) confirm that is taking place on spring (April-June), with a peak during late spring (May).

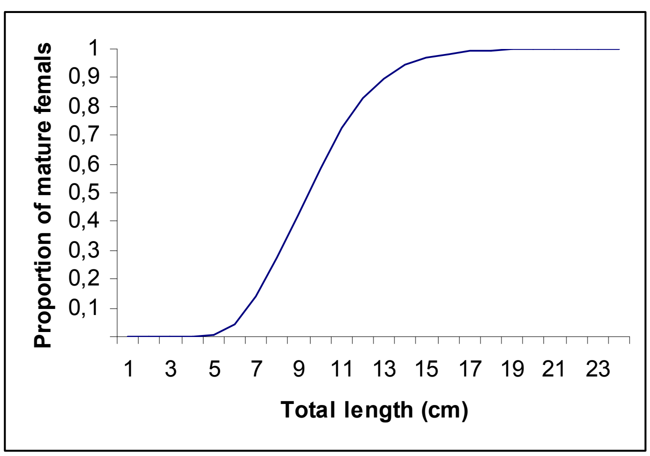


Fig. 5.23.1.3.1 Maturity ogive for females *M. barbatus* in the GSA 11.

5.23.2. Fisheries

5.23.2.1. General description of fisheries

Red mullet (*Mullus barbatus*) is among the most commercially important species in the area and forms part of an assemblage that is the target of the bottom trawling and small scale fleets, which operate near shore. Particularly, during the bulk of post-recruitment (September-October), small trawlers target this species on shallower waters, near the coasts. From 1994 to 2004, in GSA 11, the trawling-fleet has remarkably changed, with a general increase of the number of vessels and the replacement of the old, low tonnage wooden boats by larger steel boats. For the entire GSA a decrease of 20% for the smaller boats (<30 GRT), which principally exploit this species, was also observed.

5.23.2.2. Management regulations applicable in 2009 and 2010

As in other areas of the Mediterranean, the management of this stock is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06). Two small closed areas were also established along the mainland (west and east coast respectively), although these are finalised to protect lobsters mainly. Since 1991, a fishing ban for trawling 45 day was have been almost every year enforced in different periods for the small scale fishery (March, TSL<=15) and for the big trawlers (September, TSL<15). In the following figure, differences in the closure regime are shown; a red point means that no fishing ban measure has been adopted for that particular year.

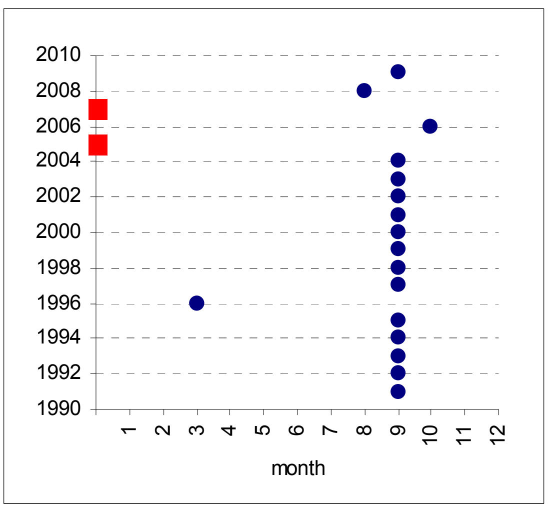


Fig. 5.23.2.2.1 Differences in the closure regime are shown; a red point means that no fishing ban measure has been adopted for that particular year.

Furthermore, recently (2006) the closure was differentiate also considering different coast (west and east mainly) with a shift of 15 days of the fishing ban period. Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

5.23.2.3. Catches

5.23.2.3.1. Landings

Landings data from 2009 were not submitted by the Italian authorities. Landings for GSA 11 by major fishing gears are listed in Tab. 5.23.2.3.1.1. Since 2002, landings increased from 360 t to 930 t in 2005 and decreased to 340 t in 2008 (Fig. 5.23.2.3.1.1). Landings are dominated by demersal trawl fisheries (DTS, OTB and partially PMP). According to the STECF-SGMED scientist's knowledge, DCF data for GSA 11 seems to underestimate landings derived from LLS, GNS and GTR. Both a check made by experts of the official data and an update of information are needed to improve and facilitate the work in next SGMED meetings.

Tab. 5.23.2.3.1.1 lists landings by fishing technique. The data were not updated for 2009 and were the same reported to SGMED-09-02 through the Data Collection Framework. Since 2002 the annual landings varied between 115 and 354 t. The landings were mainly from demersal otter trawls (catches from other gears are less than 5% of the total).

Tab. 5.23.2.3.1.1 Annual landings (t) by fishing technique in GSA 11, 2002-2008 as reported through DCF.

FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DTS	38	253					
FPO						3	1
FYK						5	1
GNS			3				
GTR			11	13	13	0	1
OTB			333	253	249	346	263
PGP	0						
PMP	77	68					
total landings (all gears)	115	321	347	266	262	354	266

Tab. 5.23.2.3.1.2 Annual landings (t) by fishing technique in GSA 11, 2004-2008 as reported through the official DCF data call in 2010.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	11	ITA	FPO	DEMSP							3	1	
MUT	11	ITA	FYK	DEMSP							5	1	
MUT	11	ITA	GNS	DEMSP				3					
MUT	11	ITA	GTR	DEMSP				11	13	13	0	1	
MUT	11	ITA	OTB	DEMSP				157	88	89	11	186	
MUT	11	ITA	OTB	DWSP								1	
MUT	11	ITA	OTB	MDDWSP				176	164	161	335	76	
Sum								347	265	263	354	266	

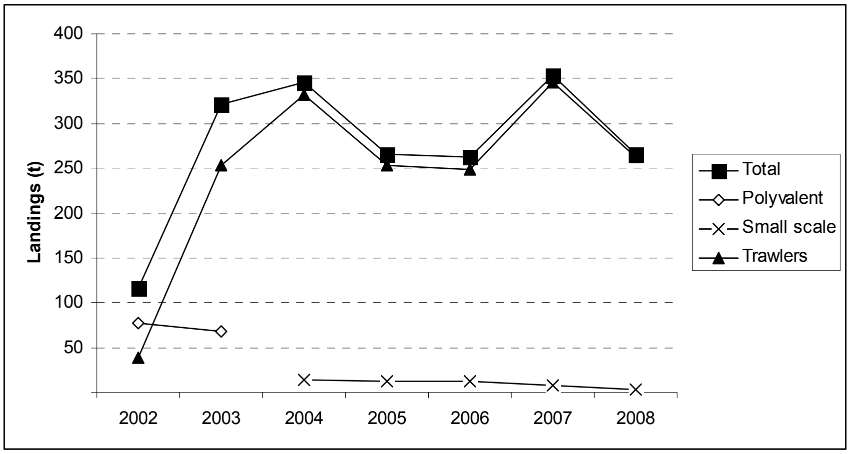


Fig. 5.23.2.3.1.1 Landings (t) by year and major gear types, 2002-2008 as reported through DCR.

5.23.2.3.2. Discards

No new data update from the DCF data call of SGMED-10-02 was available. Low discards quantities (7 t) were reported through DCR and for 2006 only.

5.23.2.3.3. Fishing effort

The reported fishing effort values through the DCF data call to SGMED-10-02 was not updated for 2009. Some effort data for 2008 were reported just few days before the meeting, however a first check of the data highlight incongruous information between SGMED-09-03 and SGMED-10-02 data call. Moreover, SGMED-10-02 noted a clear underestimation for OTB effort (days), and thus 2008 data were not used. The trends in fishing effort by fishing technique are the same reported to SGMED-09-02 and are listed in Tab. 5.23.2.3.3.1. The effort of the major trawler fleet has doubled during 2003-2004 and stayed at the high level thereafter.

Tab. 5.23.2.3.3.1 Trends in annual fishing effort by fishing technique deployed in GSA 11, 2002-2007.

FT_LVL4	2002	2003	2004	2005	2006	2007
FPO				79031	824017	1387022
FYK						13055
GND						11713
GNS				1007963	236313	781402
GTR				6358014	6476994	4393484
LHP-LHM				769	70523	122621
LLD				284297	480411	952876
LLS				832709	1159412	1054615
LTL					12388	1622
OTB				7679721	5879355	5957347
DTS	3679604	4652647	6711626			
PGP	2865738	5099814	7105771			
PMP	7159338	3245118				
total	13704680	12997579	13817397	16242504	15139413	14675757

Tab. 5.23.2.3.3.2 Trends in annual fishing effort by fishing technique deployed in GSA 11, 2004-2008, as reported through the official DCF data call in 2010.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
11	ITA	FPO	DEMSP		VL0006					8227	1107	
11	ITA	FPO	DEMSP		VL0612				13379	69823	43856	
11	ITA	FPO	DEMSP		VL1218					16165	4731	
11	ITA	FYK	DEMSP		VL0006						0	
11	ITA	GNS	DEMSP		VL0006				0	3950	2439	
11	ITA	GNS	DEMSP		VL0612		22701	54787	5413	44336	35469	
11	ITA	GNS	DEMSP		VL1218		5248	39173	9568	7130	19593	
11	ITA	GTR	DEMSP		VL0006				5465	5988	4328	
11	ITA	GTR	DEMSP		VL0612			38115	82656	176487	116844	
11	ITA	GTR	DEMSP		VL1218		1814	54332	19069	75188	64023	
11	ITA	LHP-LHM	CEP		VL0006					4305	1131	
11	ITA	LHP-LHM	CEP		VL0612		3065		2611	9764	3353	
11	ITA	LHP-LHM	CEP		VL1218					12237	4371	
11	ITA	LHP-LHM	FINF		VL0612						3480	
11	ITA	LLD	LPF		VL1218			6694				
11	ITA	LLD	LPF		VL2440					1975		
11	ITA	LLS	DEMF		VL0006				228	2263	0	
11	ITA	LLS	DEMF		VL0612		50046	61709	4253	76836	29234	
11	ITA	LLS	DEMF		VL1218		3499	34499	20040	43290	25525	
11	ITA	LLS	DEMF		VL2440					13170		
11	ITA	OTB	DEMSP		VL1218		75568	77835	108842		95470	
11	ITA	OTB	DEMSP		VL1824						66067	
11	ITA	OTB	DEMSP		VL2440						22082	
11	ITA	OTB	MDDWSP		VL1218					152444	8561	
11	ITA	OTB	MDDWSP		VL1824		115969	188926	141391	195889	35045	
11	ITA	OTB	MDDWSP		VL2440		213246	234872	190232	187054	126564	
11	ITA	PS	SPF		VL1218		4109					

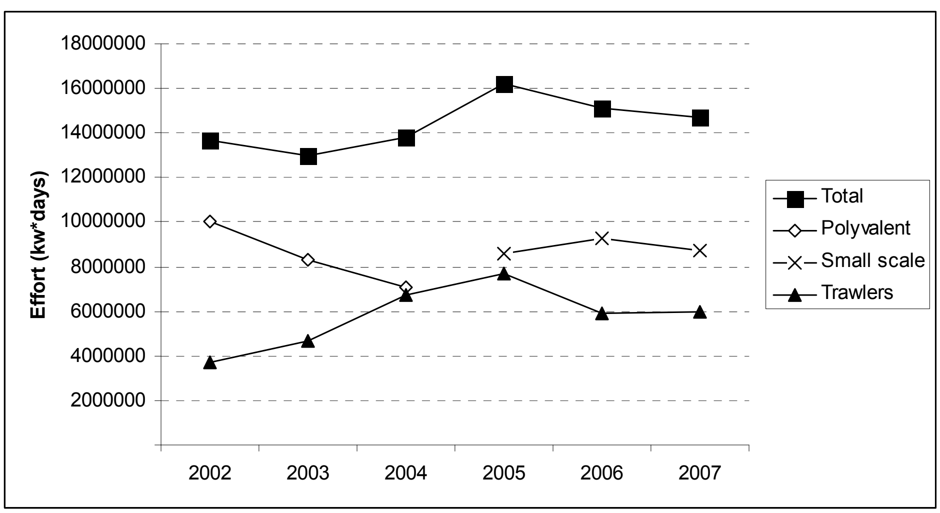


Fig. 5.23.2.3.3.1 Trend in fishing effort (kW·days) for Italy by major gear types, 2002-2007.

5.23.3. Scientific surveys

5.23.3.1. MEDITS

5.23.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated and presented in this report. In GSA 11 the following number of hauls on shelf bottoms was reported per depth stratum (s. Tab. 5.23.3.1.1.1).

Tab. 5.23.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18
GSA11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20
GSA11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24
GSA11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19
GSA11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Only hauls noted as valid were used, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length

frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.23.3.1.2. Geographical distribution patterns

The spatial structure of red mullet have been achieved by modelling the spatial correlation structure of the abundance indices through geostatistical techniques, showing clear areas of persistence in the south (Gulf of Cagliari) and western coasts (Carloforte and coast between Bosa Marina and Capo Mannu). Main results and maps are reported in the “nursery section” of SGMED-09-02 report.

5.23.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 11 was derived from the international survey MEDITS. Figure 5.23.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 11. The estimated abundance and biomass indices do not reveal any significant trends. However, the recent abundance and biomass indices since 2005 appear high but are subject to high uncertainty.

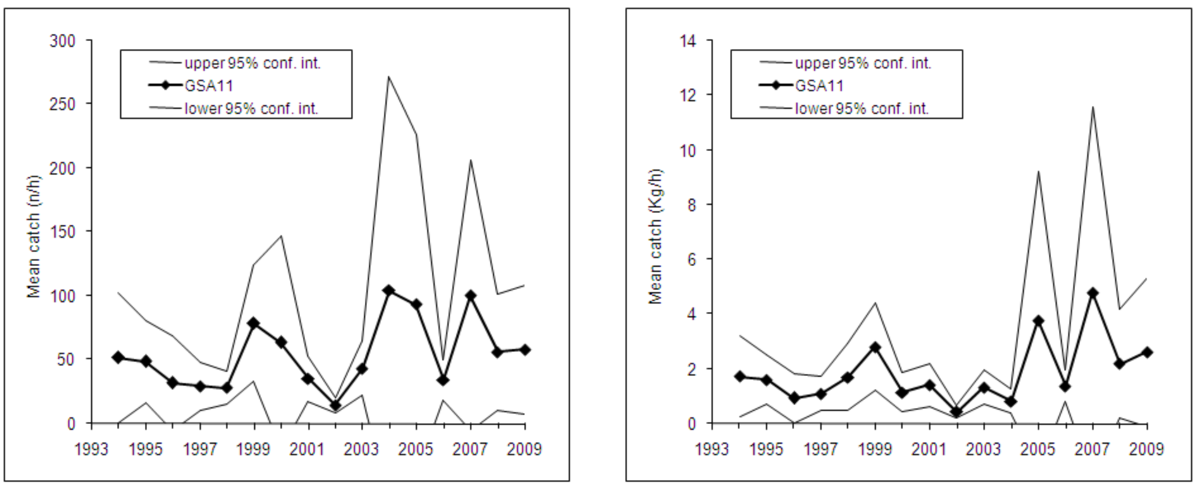


Fig. 5.23.3.1.3.1 Abundance and biomass indices of red mullet in GSA 11.

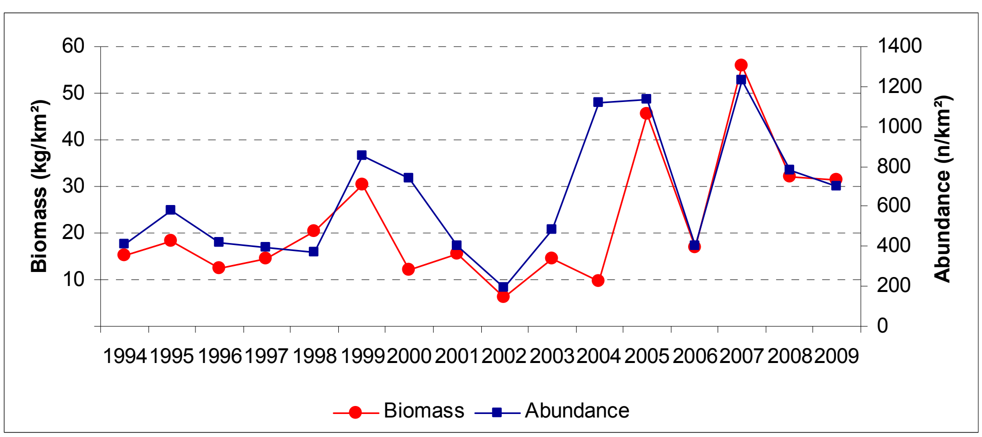


Fig. 5.23.3.1.3.2 Abundance and biomass indices of red mullet in GSA 11.

5.23.3.1.4. *Trends in abundance by length or age*

The following Fig. 5.23.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2001 and 2002-2009.

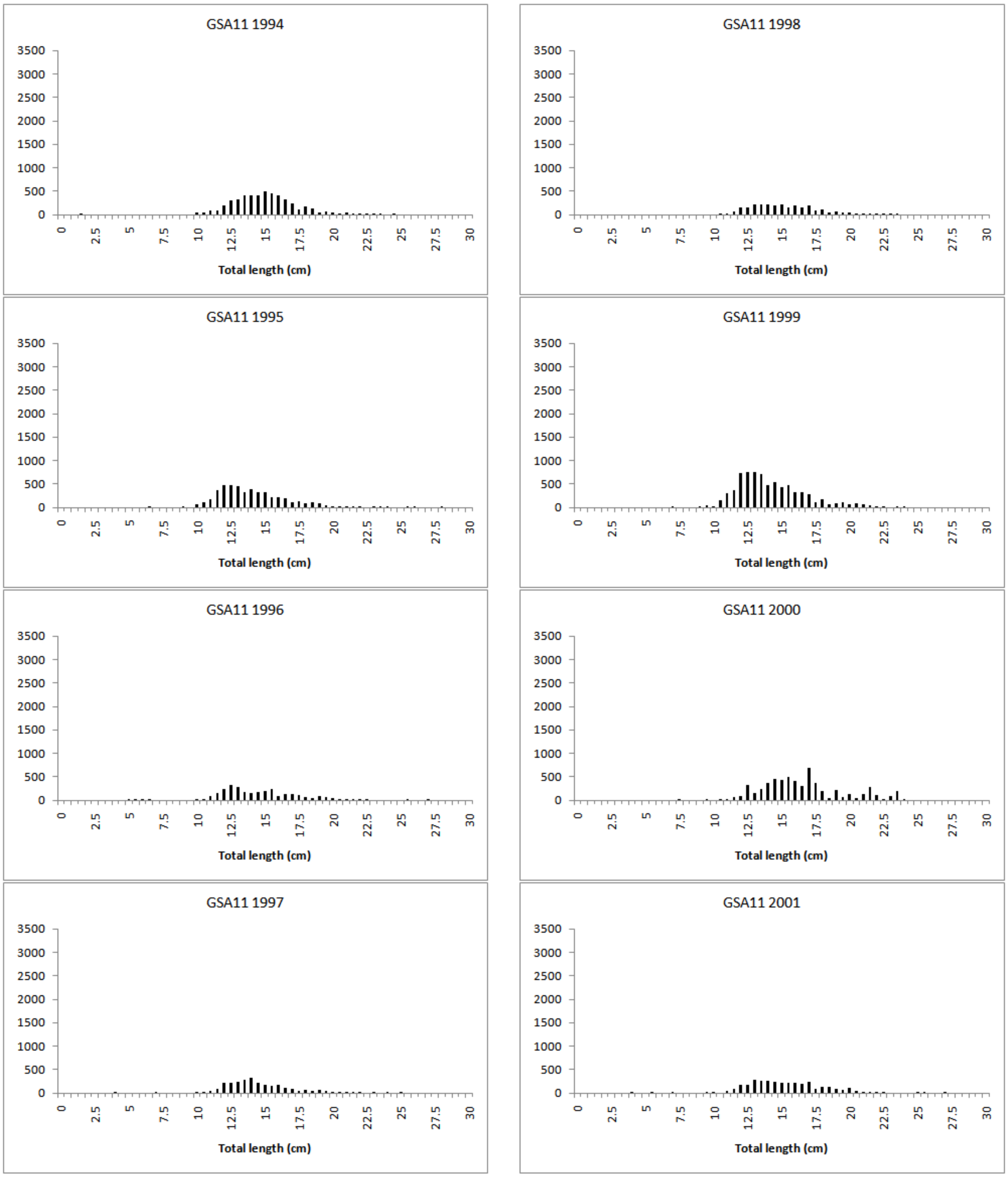


Fig. 5.23.3.1.4.1 Stratified abundance indices by size, 1994-2001.

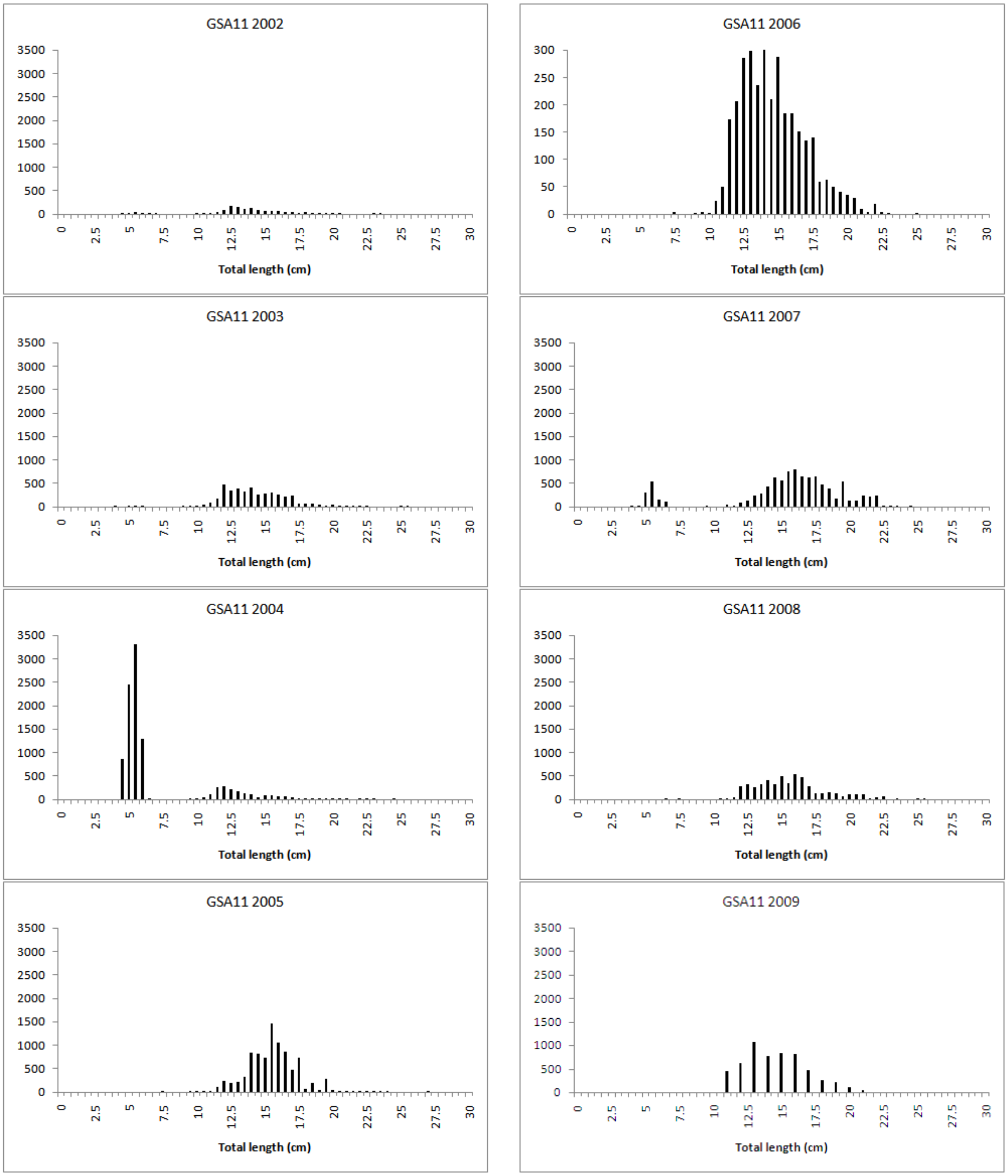


Fig. 5.23.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.23.3.1.5. Trends in growth

No analyses were conducted.

5.23.3.1.6. Trends in maturity

No analyses were conducted.

5.23.4. Assessment of historic stock parameters

5.23.4.1. Method 1: SURBA

5.23.4.1.1. Justification

The SURBA was applied to the MEDITS survey estimates.

5.23.4.1.2. Input parameters

Data from trawl surveys (time series of MEDITS from 1994 to 2009) and landings data from DCR have been used for the analysis. The SURBA software package (Needle, 2003) use trawl surveys data time series available from the MEDITS to estimate fishing mortality rates of red mullet in the GSA 11. First, the LFDs were converted in numbers at age group using the subroutine "age slicing" as implemented in the R routine by SGMED. The VBGF parameters used to split the LFD was the same used for the LCA approach used here and in SGMED-09-03. According to the Prodbiom approach (Caddy and Abella 1999), a vectorial natural mortality at age was estimated (Tab. 5.23.4.1.2.1). Guess estimates of catchability at age are given in Tab. 5.23.4.1.2.1.

Tab. 5.23.4.1.2.1. Input parameters used in the SURBA analysis (sex combined) in the GSA 11.

VBGF M vector	L_∞=29.1 cm, K=0.41, t_0= -0.39 Age_1=0.41, Age_2=0.27, Age_3=0.24, Age_4=0.21
Catchability (q)	q_{1-4} = 1
Length at maturity (L50)	13 cm (sex combined)

5.23.4.1.3. Results

SURBA output show that the mean F for ages 1-3 was varying until 2001 with a clear decreasing trend thereafter and an increase in 2009 (Fig. 5.23.4.1.3.1).

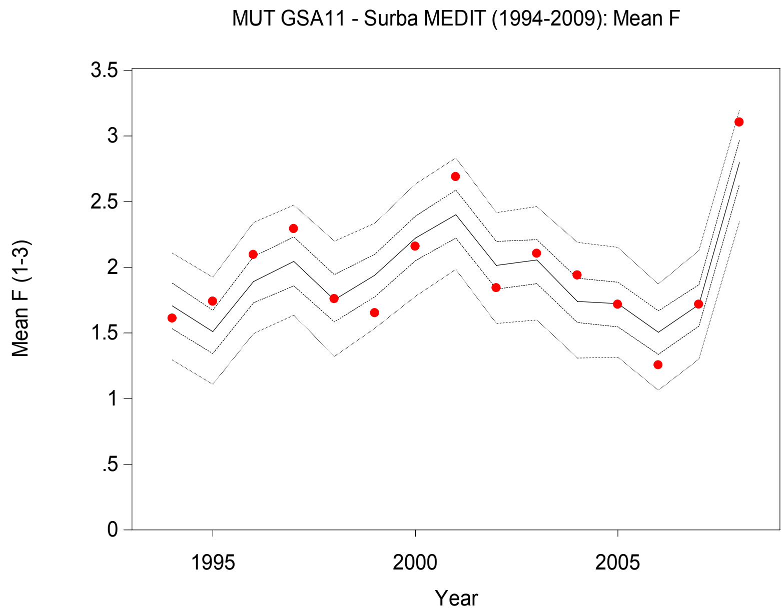


Fig. 5.23.4.1.3.1 Fishing mortalities estimated by SURBA using trawl surveys age composition (MEDITS).

Peaks in relative SSB has been detected in 1999 and 2007, as show below in Fig. 5.23.4.1.3.2.

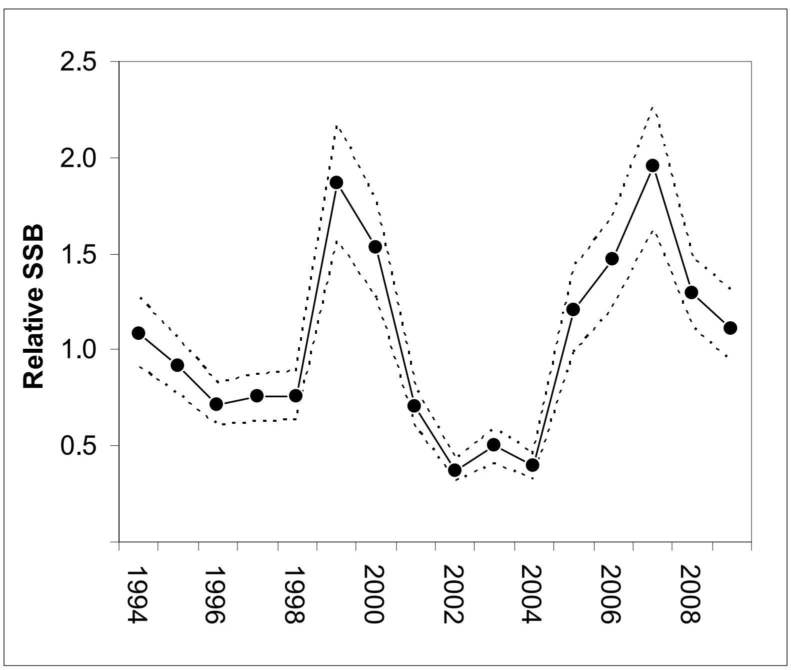
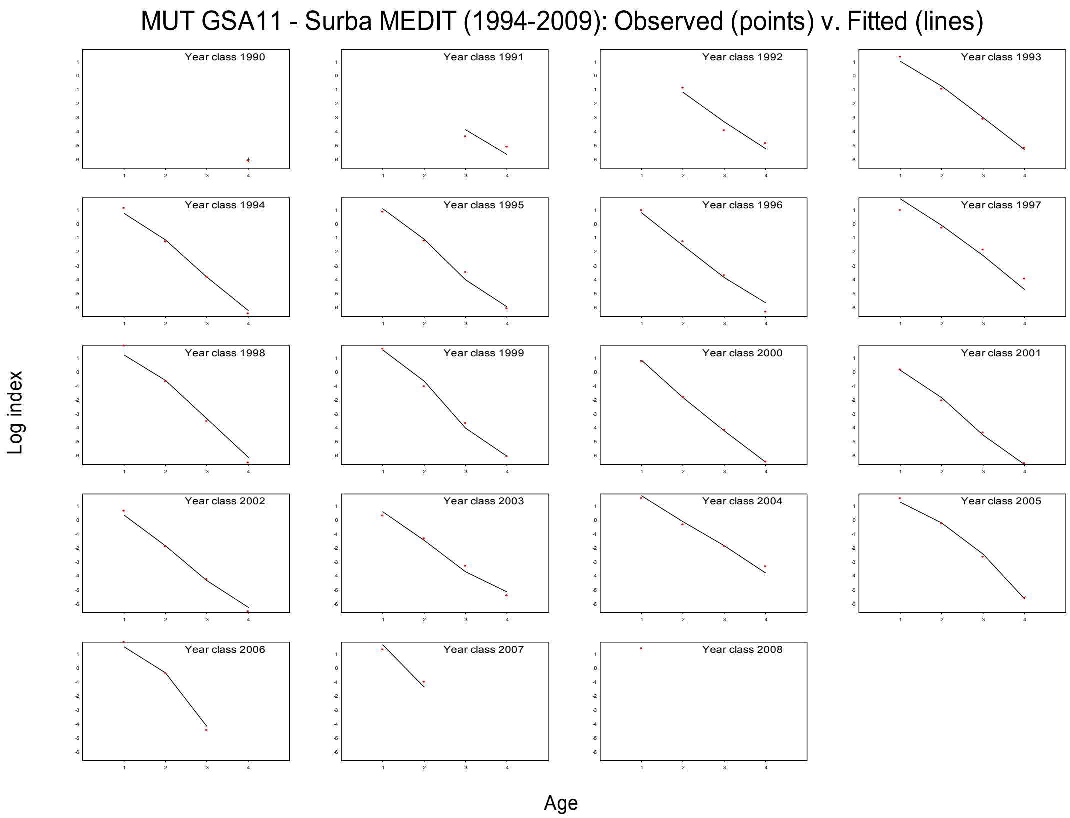


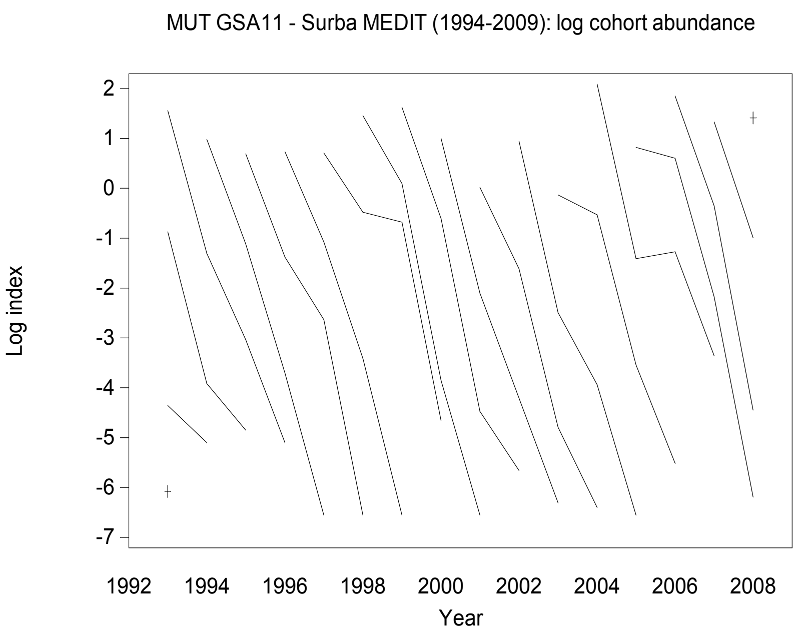
Fig. 5.23.4.1.3.2 Trend of SSB estimated by SURBA using trawl surveys age composition (MEDITS).

Since the survey period is close to the spawing period, the relative recruitment indices were not shown.

Model diagnostics are presented in Fig. 5.23.4.1.3.3. Observed and fitted MEDITS survey indices of abundance for each year were reasonably in agreement (A) while catch curve reconstruction from log survey abundance indices showed some deviation from the expected curve (B). Log index residuals over time, plotted by age class (C) varied without any trend.


MUT GSA11 - Surba MEDIT (1994-2009): Observed (points) v. Fitted (lines)
Year class 1990
Year class 1991
Year class 1992
Year class 1993
Year class 1994
Year class 1995
Year class 1996
Year class 1997
Year class 1998
Year class 1999
Year class 2000
Year class 2001
Year class 2002
Year class 2003
Year class 2004
Year class 2005
Year class 2006
Year class 2007
Year class 2008
Log index
Age

A


MUT GSA11 - Surba MEDIT (1994-2009): log cohort abundance
Log index
Year
2
1
0
-1
-2
-3
-4
-5
-6
-7
1992
1994
1996
1998
2000
2002
2004
2006
2008

B

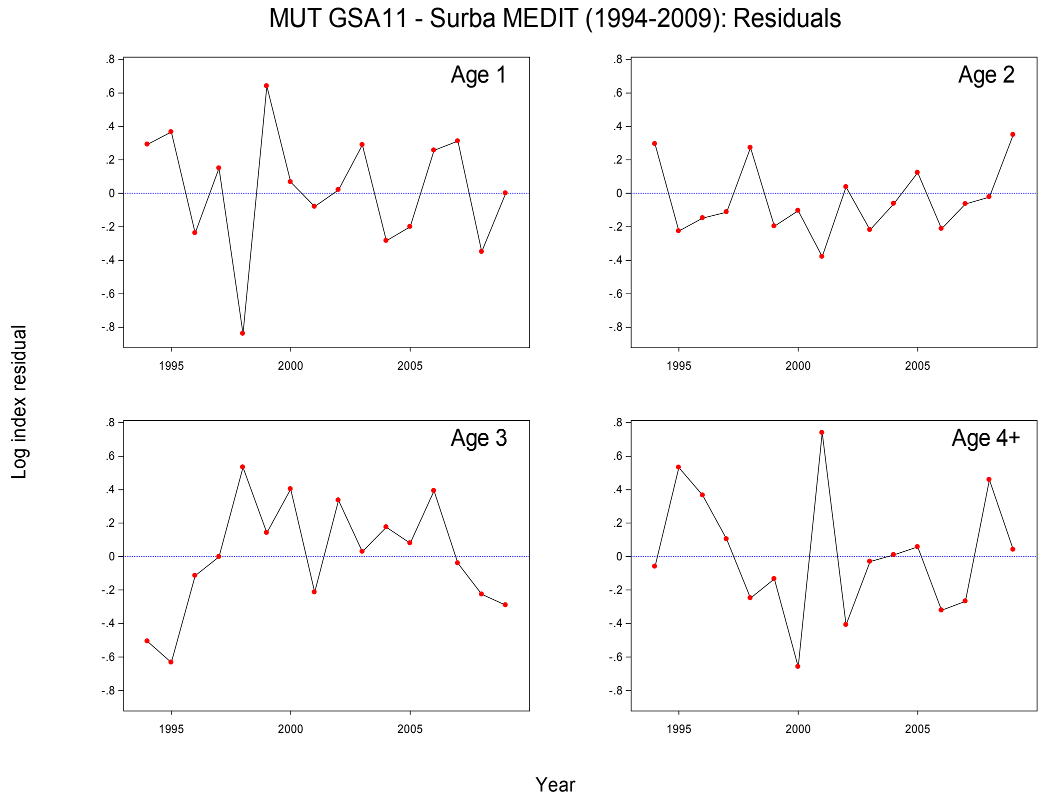


Fig. 5.23.4.1.3.3 Model diagnostic for SURBA model in the GSA 11 (MEDITS survey). A) Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life. C) Log index residuals over time by age class.

5.23.4.2. Method 1: VIT LCA

5.23.4.2.1. Justification

An approach under steady state (pseudocohort) assumption was applied due to the shortness of landing by length and age (2006-2007 only, DCR) data. Pseudocohort, LCA and Y/R analyses as been carried out with VIT software for trawl fishery only. No discard data were included and a plus group has been used. Landings from 2009 were not submitted by the Italian authorities, thus SGMED was unable to carry out an update of the VIT analysis for 2009.

5.23.4.2.2. Input parameters

According to the Prodbiom approach by Caddy and Abella (1999), a vectorial natural mortality at age was computed for the stock analysis (Tab. 5.23.4.2.2.1). Terminal F was fixed to 0.6.

Tab. 5.23.4.2.2.1 Input parameters used of the analysis (sex combined) in the GSA11.

VBGF M vector	L_∞=29.1 cm, K=0.41, t_0= -0.39 Age_0=1.3, Age_1=0.41, Age_2=0.27, Age_3=0.24, Age_4=0.21
Length at maturity (L50)	13 cm (sex combined)

Tab. 5.23.4.2.2.2 Catch numbers at length in 2006 and 2007.

length	age	2006	2007
11	0	420	873
12	1	784	847
13	1	1408	2089
14	1	1026	1073
15	1	762	1244
16	1	761	1355
17	1	455	810
18	2	269	379
19	2	324	486
20	2	52	94
21	2	5	35
22	3	10	12
23	3	10	23
24	3	10	

5.23.4.2.3. Results including sensitivity analyses

Results obtained by year were very different from those obtained by the mean pseudocohort highlighting problem related to data collection or an important interannual variation of the exploitation pattern.

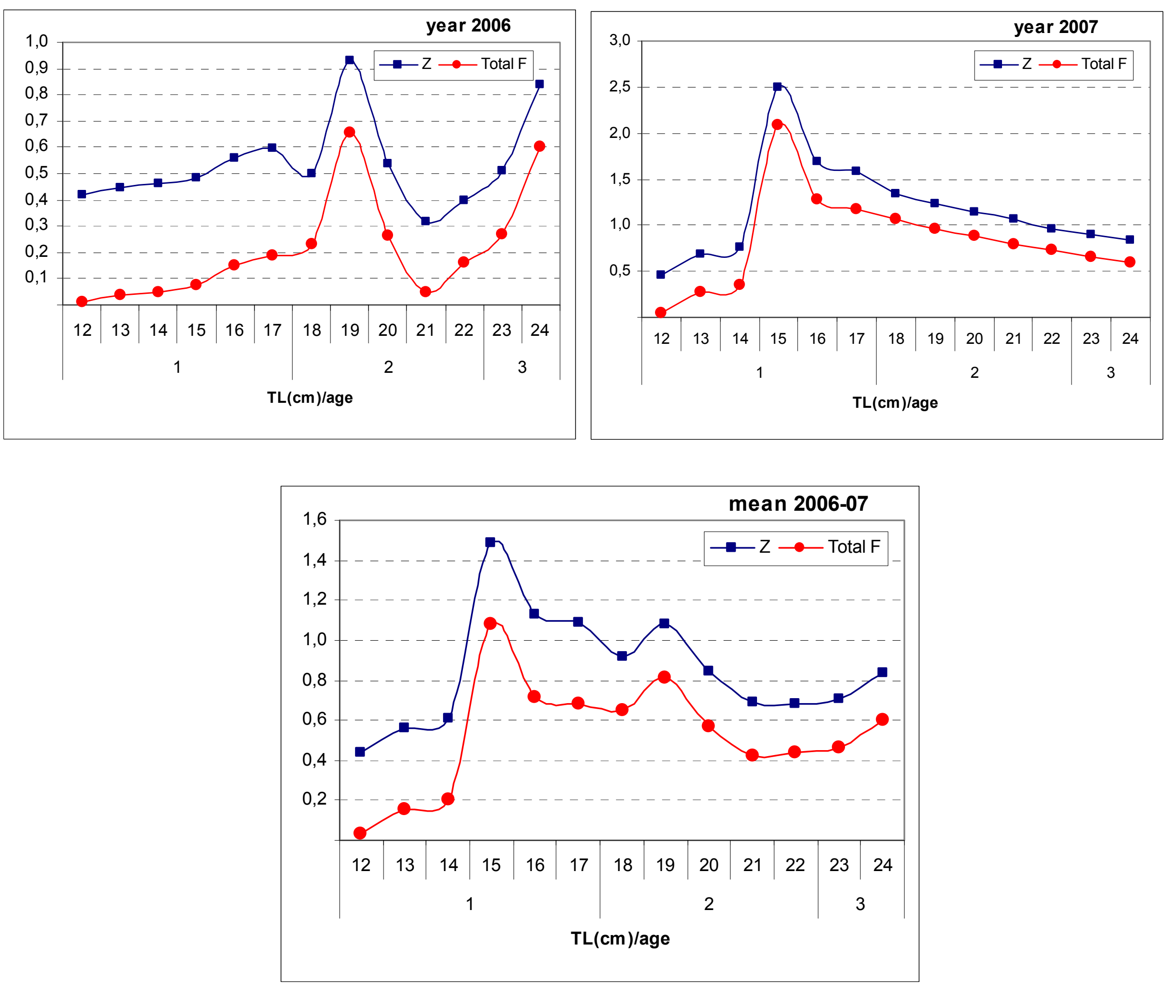


Figure 5.23.4.2.3.1 Fishing (F) and total mortality (Z) rates by size and year in GSA11 (age groups 1-3).

Although from 2006 to 2007 an increase of 29% of the OTB effort occurred, the great raise of $F_{(1\text{-}3)}$ (0.2 in 2006 and 0.83 in 2007) seems unrealistic.

Table 5.23.4.2.3.1 Estimated fishing mortaliy in 2006 and 2007 as well as the mean of both years.

	2006	2007	Mean 06-07
$F_{(1\text{-}3)}$	0.2	0.83	0,524

5.23.5. Long term prediction

5.23.5.1. Justification

Equilibrium YPR reference points for the stock were estimated through the Yield software (Hoggarth *et al.*, 2006).

5.23.5.2. Input parameters

The growth and L/W parameters previously defined in the biological features section (Table 5.23.1.2.1) were used, while a weighted mean value of M of 0.6 was used instead of an M-at-size vector. Age at maturity was set as 1 and age at first capture was 0.7.

5.23.5.3. Results

Reference fishing mortality (F_{ref}) and the referent points $F_{0.1}$ and the F_{max} are listed below.

$F_{0.1}$	0.322
F_{max}	0.502
F_{ref}	0.427

5.23.6. Data quality and availability

Landings data from 2009 were not submitted by the Italian authorities. The lacking of a good and long time series of landings and the absence of landing data by length/age data for the small scale fishery make difficult to perform reliable assessments using the traditional methods. Moreover is clear that DCR DCF data report underestimated landings by the artisanal fishery (LLS, GNS and GTR) because the magnitude of effort is 5 time more than the effort of OTB, while catches are less than 5% of the total. Finally the update of some approaches was not possible because landings from 2009 were not submitted to SGMED. All this highlight the lack of checking procedure of the official data as well as the need to improve the sampling design or the survey collection of commercial catches.

The availability and quality of survey data (MEDITS) was appropriate. Due to the fact that the survey has been generally carried out in late spring and did sample the bulk of the recruitment of the species, the assessment of the recruits from the SURBA analysis is not presented. The use of other survey results (GRUND) should help further to update the information and should be encouraged.

5.23.7. Scientific advice

5.23.7.1. Short term considerations

5.23.7.1.1. State of the spawning stock size

SGMED could not estimate the absolute levels of stock abundance. MEDITS survey abundance (n/km^2) and biomass (kg/km^2) indices which should be considered as a proxy of the spawning stock biomass, show high variability throughout the time series. Two peaks of SSB are detected in 1999 and 2007. SGMED is unable to fully evaluate the status of the SSB in the absence of precautionary management reference points.

5.23.7.1.2. State of recruitment

SGMED is unable to provide any scientific advice of the state of recruitment given the preliminary state of the data and analyses.

5.23.7.1.3. State of exploitation

SGMED proposes $F_{0.1}$=0.32 of ages 1-3 as limit management reference point consistent with high long term yields. Taking into account the results from SURBA the stock of red mullet in GSA 11 is considered overexploited until 2008.

5.24. Stock assessment of red mullet in GSA 16

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.24.1. Stock identification and biological features

5.24.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.24.1.2. Growth

No information was documented during SGMED-10-02.

5.24.1.3. Maturity

No information was documented during SGMED-10-02.

5.24.2. Fisheries

5.24.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.24.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.24.2.3. Catches

5.24.2.3.1. Landings

Landings data were reported to SGMED-10-02 through the Data Collection Framework. Annual landings decreased from 1,626 t in 2004 to 1,177 t in 2008 (Tab. 5.24.2.3.1.1). Demersal otter trawlers dominate the landings by far.

Table 5.24.2.3.1.1 Annual landings (t) by fishing technique as reported to SGMED-10-02 through the DCR data call.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	16	ITA	GTR	DEMSP				58	29	39	37	20	
MUT	16	ITA	OTB	DEMSP				104	60	37		1035	
MUT	16	ITA	OTB	DWSP								1	
MUT	16	ITA	OTB	MDDWSP				1464	1316	1047	1343	121	
Sum								1626	1405	1123	1380	1177	

5.24.2.3.2. Discards

Discards data were reported for 2006 to 2008.

Tab. 5.24.2.3.2.1 Discards data by fishing technique in GSA 16.

SPECIES	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
MUT	16	ITA	OTB					94	117	101

5.24.2.3.3. Fishing effort

Tab. 5.24.2.3.3.1 lists the effort by fishing technique deployed in GSA 16 as reported to SGMED-10-02 throught the DCR data call. The main gear demersal otter trawl does not reveal any significant trend in effort deployed.

Tab. 5.24.2.3.3.1 Effort (kW*days) trends by fishing technique in GSA 16, 2004-2008.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
16	ITA				VL0612			3886			417	
16	ITA	GTR	DEMSP		VL0006				8548	9979	12285	
16	ITA	GTR	DEMSP		VL0612		164944	178522	76073	103953	103352	
16	ITA	GTR	DEMSP		VL1218		25926	7720	23894	18868	8189	
16	ITA	GTR	DEMSP		VL1824			1420				
16	ITA	LHP-LHM	CEP		VL0006				525	1162		
16	ITA	LHP-LHM	FINF		VL0612		16931	16553	14973	15019	21934	
16	ITA	LHP-LHM	FINF		VL1218		641					
16	ITA	LLD	LPF		VL1218		12401	3900	2924	3435	16936	
16	ITA	LLD	LPF		VL1824		36304	5756	1029	78320	12919	
16	ITA	LLS	DEMF		VL0006				1022	3942	1394	
16	ITA	LLS	DEMF		VL0612		26733	58661	12698	57631	9512	
16	ITA	LLS	DEMF		VL1218		21984	1640	3115	62773	18439	
16	ITA	LLS	DEMF		VL1824		1870					
16	ITA	OTB	DEMSP		VL1218		210042	238629	272220		263191	
16	ITA	OTB	DEMSP		VL1824		54367	13425			397440	
16	ITA	OTB	DEMSP		VL2440						693213	
16	ITA	OTB	DWSP		VL1824						15246	
16	ITA	OTB	DWSP		VL2440						41113	
16	ITA	OTB	MDDWSP		VL1218					285378	4336	
16	ITA	OTB	MDDWSP		VL1824		377936	418914	434834	549867	93949	
16	ITA	OTB	MDDWSP		VL2440		1116269	1161841	442196	1484331	225904	
16	ITA	OTM	MDPSP		VL1824				21611	26555	41792	
16	ITA	OTM	MDPSP		VL2440		5306		9096			
16	ITA	PS	LPF		VL1824						9763	
16	ITA	PS	SPF		VL0006						397	
16	ITA	PS	SPF		VL0612			8471		670	3127	
16	ITA	PS	SPF		VL1218		1772	1997	1355		2354	
16	ITA	PS	SPF		VL1824		17339	12429	7349	39307	11625	
16	ITA	PTM	SPF		VL1824			19612	72116	107330	38857	

5.24.3. Scientific surveys

5.24.3.1. Medits

5.24.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 16 the following number of hauls was reported per depth stratum (s. Tab. 5.24.3.1.1.1).

Tab. 5.24.3.1.1.1. Number of hauls per year and depth stratum in GSA 16, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA16_010-050	4	4	4	4	4	4	4	4	7	7	7	10	10	11	11	11
GSA16_050-100	9	8	8	8	8	8	7	8	11	12	12	20	22	23	23	23
GSA16_100-200	4	4	4	4	5	5	6	5	11	10	11	20	19	21	21	21
GSA16_200-500	10	11	11	12	11	11	11	11	19	18	26	37	31	27	27	27
GSA16_500-800	10	14	14	13	14	14	14	14	20	20	21	33	33	38	38	38

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.24.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.24.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 16 was derived from the international survey Medits. Figure 5.24.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 16.

The estimated abundance and biomass indices reveal a significant increasing trend since 1999.

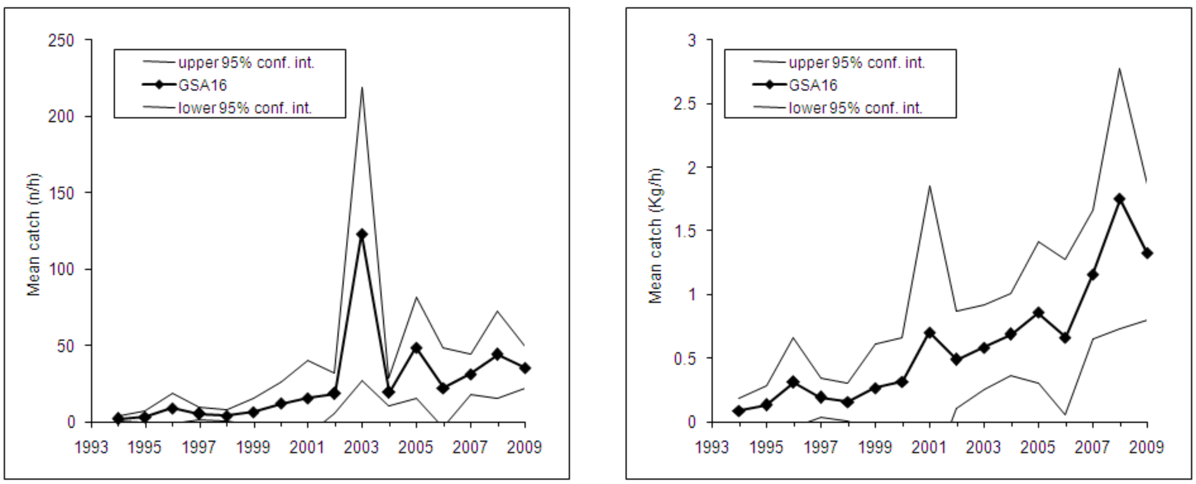


Fig. 5.24.3.1.3.1 Abundance and biomass indices of red mullet in GSA 16.

5.24.3.1.4. Trends in abundance by length or age

The following Fig. 5.24.3.1.4.1 and 2 display the stratified abundance indices by size of GSA 16 in 1994-2001 and 2002-2009. These size compositions are considered preliminary.

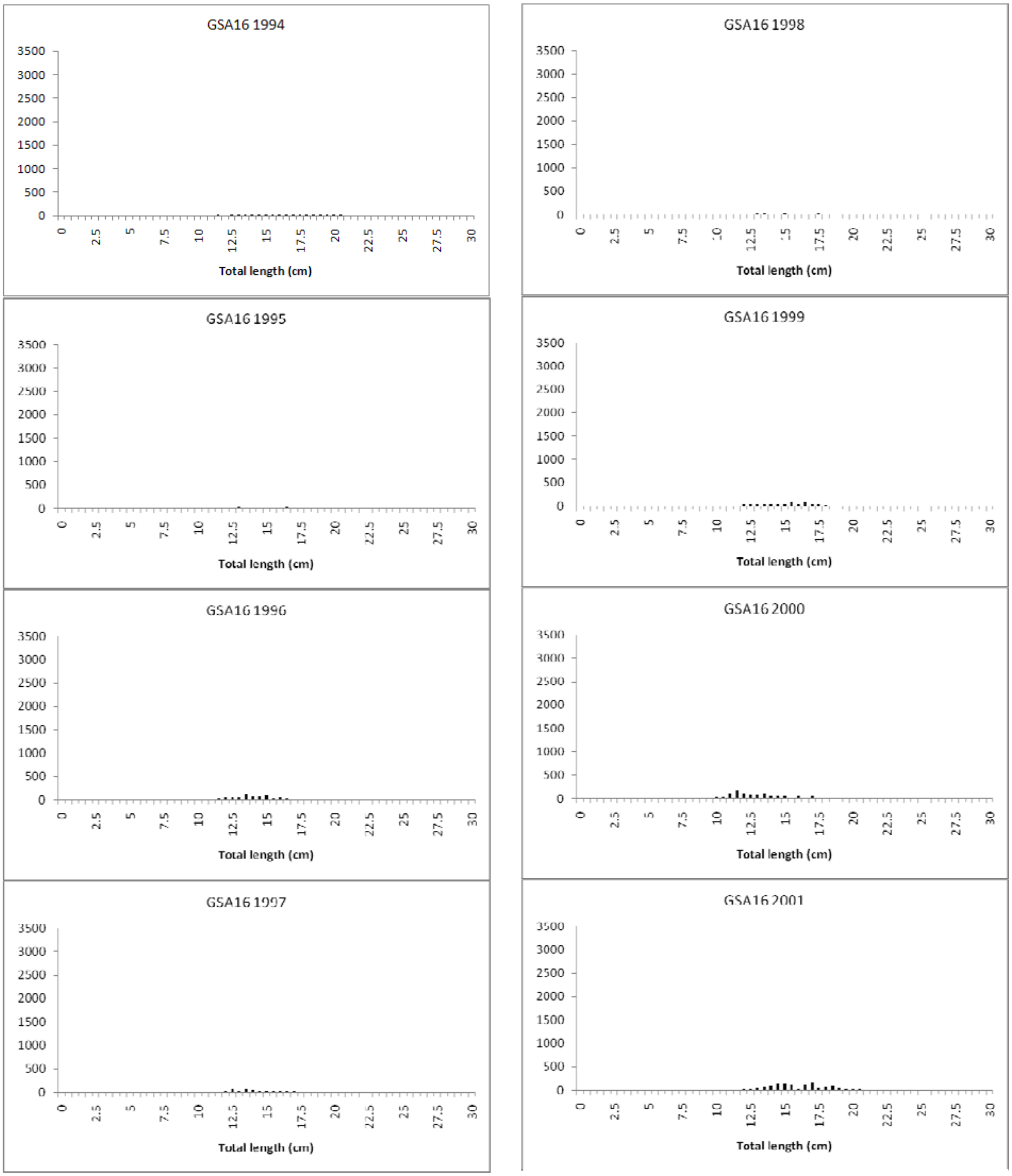


Fig. 5.24.3.1.4.1 Stratified abundance indices by size, 1994-2001.

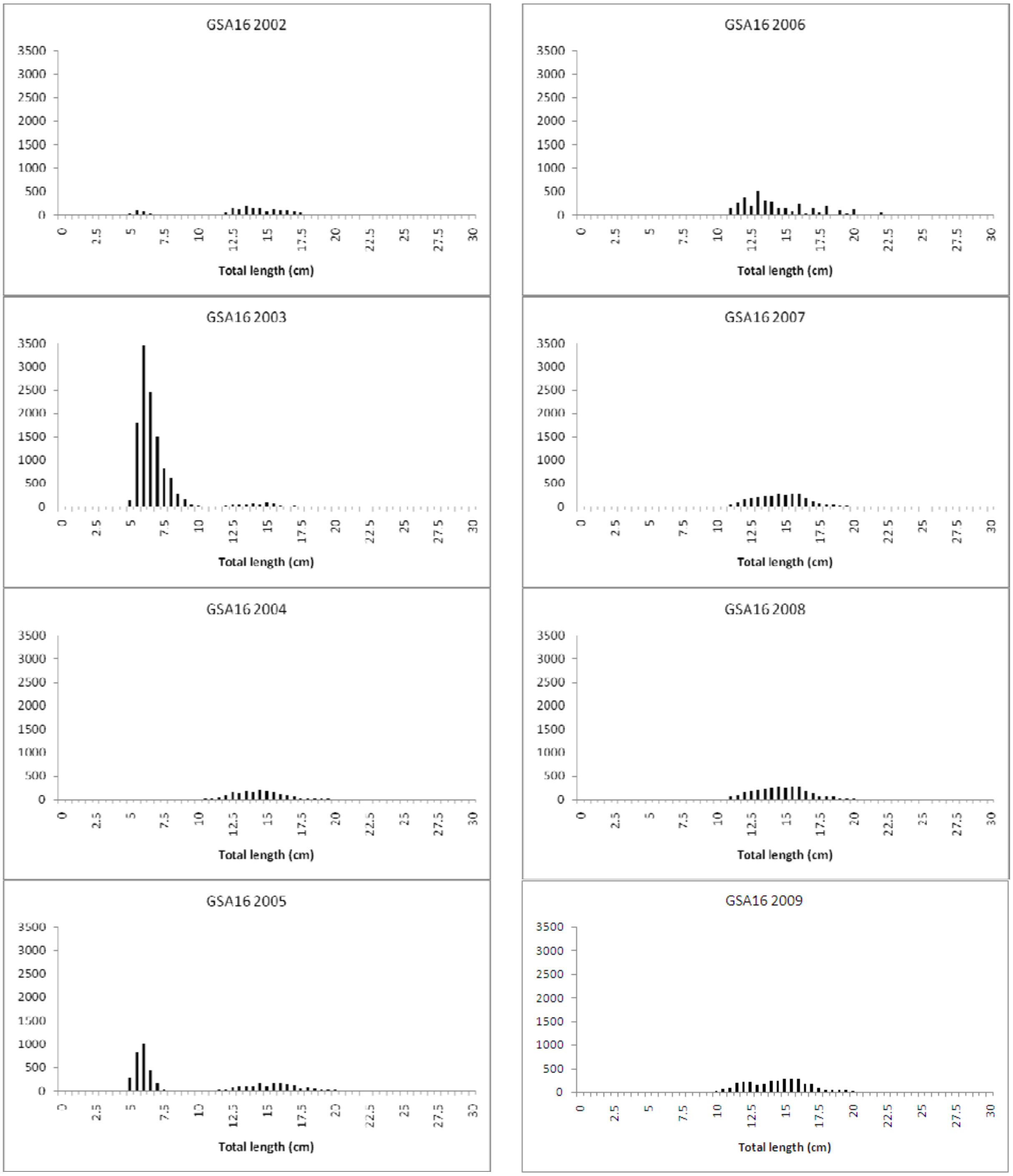


Fig. 5.24.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.24.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.24.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.24.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.24.5. Long term prediction

5.24.5.1. Justification

No forecast analyses were conducted.

5.24.5.2. Input parameters

No forecast analyses were conducted.

5.24.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for red mullet in GSA 16.

5.24.6. Scientific advice

5.24.6.1. Short term considerations

5.24.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses. However, stock abundance and biomass indices dispay an increase since 1999.

5.24.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.24.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation given the preliminary state of the data and analyses.

5.25. Stock assessment of red mullet in GSA 17

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.25.1. Stock identification and biological features

5.25.1.1. Stock Identification

Red mullet is found across the whole GSA 17. However, patterns of abundance are observed over seasons and space. Along the eastern side of Adriatic, abundance seems to be relatively constant over the year. Along the western side, in late summer and autumn, large concentrations of individuals are observed in the shallow waters along the coast, whereas, in the subsequent months, a migration towards deeper waters occurs (Arneri and Jukic, 1986; SEC (2002) 1374; see also below).

The distribution of red mullet (*Mullus barbatus*) in the GSA 17, in spring-summer, is shown in the maps below (Fig. 5.25.1.1.1), imported from Sabatella and Piccinetti (2004). The picture on the left shows the depth contours, increasing with darker colour (0-50, 50-100, 100-200, > 200 m). The picture on the right displays mullet densities at sea from the MEDITS trawl survey in the second half of the 1990s, expressed as number of individuals per square kilometer.

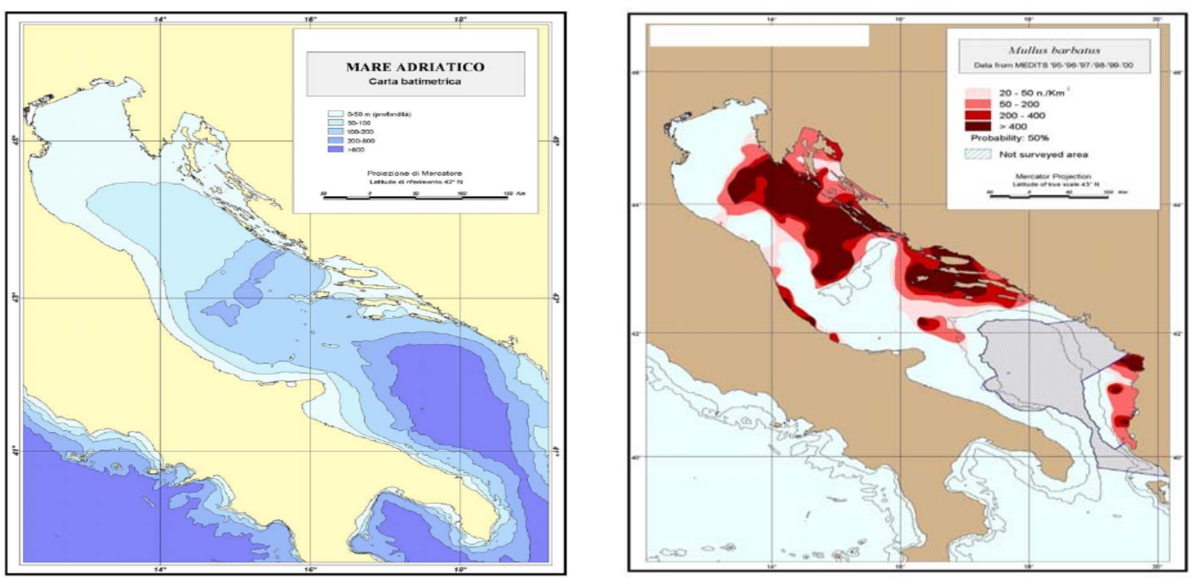


Fig. 5.25.1.1.1 Topography and geographical distribution patterns of red mullet in GSA 17.

Spawning of red mullet occurs in late spring and summer (Vrgoc *et al.*, 2004). In particular, the life cycle is characterized by the occurrence of juveniles in shallow coastal waters in late summer and autumn, and subsequent occurrence of adult individuals offshore in deeper waters during winter and spring months ((SEC (2002) 1374).

5.25.1.2. Growth

No information was documented during SGMED-10-02.

5.25.1.3. Maturity

The summary of the values of length at the first sexual maturity estimated for the Adriatic Sea was imported from Vrgoc *et al.* (2004) and listed in Table 5.25.1.3.1.

Tab. 5.25.1.3.1 Length and age at maturity and literature references.

Author	Sex	L_m (cm)	Age (yr)
Zei and Sabioncello, 1940	M+F	11-14	1
Scaccini, 1947a	M+F		2
Županović, 1963	M	11-12	
	F	12-13	
Haidar, 1970	M	10.5	1
	F	12	1
Jukić and Piccinetti, 1981	M	10.5	1
Marano *et al.*, 1998b, c	M+F	11-14	
Relini *et al.*, 1999	M	11-13	1
	F	12-14	1
Vrgoč, 2000	M	10.5-11.5	
	F	10 – 11	

5.25.2. Fisheries

5.25.2.1. General description of fisheries

The fishery for red mullet is one of the most important in the GSA 17. Fishing grounds correspond to the distribution of the stock particularly within 100 m depth. The allocation of fishing effort depends on the features of the life cycle as described above (SEC (2002) 1374).

5.25.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.25.2.3. Catches

5.25.2.3.1. Landings

Landings data were reported to SGMED-10-02 through the Data collection. Annual landings decreased from 3,884 t in 2004 to 3.236 t in 2008 (Tab. 5.25.2.3.1.1). Demersal otter trawlers dominate the landings by far. No data were provided for 2009.

Tab. 5.25.2.3.1.1 Annual landings (t) by fishing technique as reported to SGMED-10-02 through the official DCF data call, 2004-2008. Italy did not provide landings data in 2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	17	ITA							0	0	0		
MUT	17	ITA	FPO	DEMSP				1			1		
MUT	17	ITA	FYK	DEMSP					1		1	0	
MUT	17	ITA	GNS	DEMSP				35	41	12	5	7	
MUT	17	ITA	GTR	DEMSP				0	0		1	0	
MUT	17	ITA	OTB	DEMSP				2629	2975	3101	3298	3158	
MUT	17	ITA	OTB	MDDWSP				1155	599	59	25	0	
MUT	17	ITA	OTM	MDPSP						0			
MUT	17	ITA	PS	LPF					0				
MUT	17	ITA	PTM	SPF				0	4	1	0		
MUT	17	ITA	TBB	DEMSP				63	77	53	94	70	
MUT	17	SVN	FYK	DEMSP	NA					0			0
MUT	17	SVN	GNS	DEMSP	16D20					0	0	0	0
MUT	17	SVN	GTR	DEMSP	50D100				0		0	0	0
MUT	17	SVN	OTB	DEMSP	40D50				9	4	14	5	7
MUT	17	SVN	OTM	MDPSP	20D40								0
Sum								3883	3706	3230	3439	3240	7

According to FAO statistics (ftp://ftp.fao.org/fi/stat/windows/fishplus/gfcm.zip), in the northern and central Adriatic Sea, the annual landings of *Mullus* spp. (Fig. 5.25.2.3.1.1) were estimated to be over 2,000 tonnes in many years of the 1980s and 1990s. An increasing trend occurred over the 1990s.

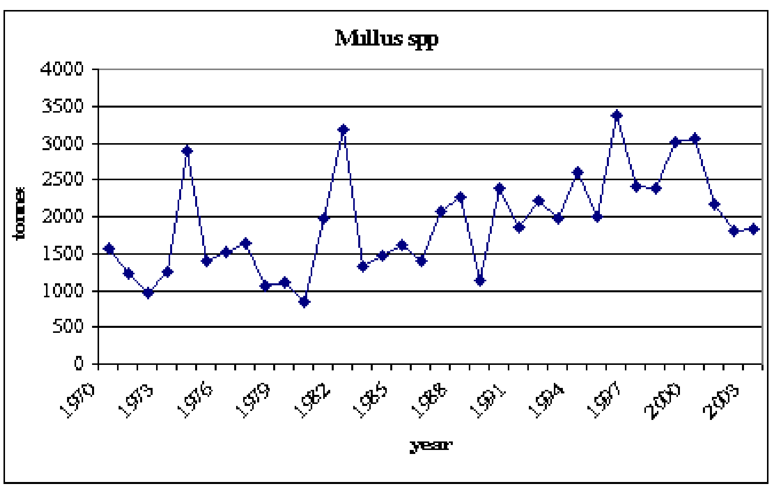


Fig. 5.25.2.3.1.1 Annual landings of red mullet in the northern and central Adriatic Sea according to FAO.

5.25.2.3.2. Discards

No discards data were reported to SGMED-10-02 for red mullet in GSA 17.

5.25.2.3.3. Fishing effort

Tab. 5.25.2.3.3.1 lists the effort by fishing technique deployed in GSA 17 as reported to SGMED-10-02 through the official DCF data call. The main gear demersal otter trawl reveals a significant decreasing trend in effort deployed.

Tab. 5.25.2.3.3.1 Effort trends (kW*days) by fishing technique in GSA 17. No data in 2009 from Italy.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
17	ITA				VL0006				28839	19464	25018	
17	ITA				VL0612		585226	426770	538249	418073	245003	
17	ITA				VL1218		21467	23352				
17	ITA				VL2440			4097		7903		
17	ITA	DRB	MOL		VL0612		19073					
17	ITA	DRB	MOL		VL1218		581702	484258	407953	612211	492480	
17	ITA	FPO	DEMSP		VL0006				130			
17	ITA	FPO	DEMSP		VL0612		19874	17355	9999	9718	18643	
17	ITA	FYK	DEMSP		VL0006				0	0	0	
17	ITA	FYK	DEMSP		VL0612		6671	333	5572	34133	14013	
17	ITA	GND	SPF		VL0612			214				
17	ITA	GNS	DEMSP		VL0006				27244	4459	16709	
17	ITA	GNS	DEMSP		VL0612		113579	97152	43173	36087	33960	
17	ITA	GNS	DEMSP		VL1218		24644	15559	7559			
17	ITA	GTR	DEMSP		VL0006				0	0		
17	ITA	GTR	DEMSP		VL0612		14415	25334	31121	34778	26522	
17	ITA	GTR	DEMSP		VL1218			7215				
17	ITA	LLD	LPF		VL0612		7472	2384			5843	
17	ITA	LLD	LPF		VL1218		961	9928	6181	3765	416	
17	ITA	LLS	DEMF		VL0612				529	498		
17	ITA	OTB	DEMSP		VL0612		143723	70376	46397	71355	67595	
17	ITA	OTB	DEMSP		VL1218		910397	713888	599979	686576	595477	
17	ITA	OTB	DEMSP		VL1824		822314	379538	639196	779138	713636	
17	ITA	OTB	DEMSP		VL2440		479467	305876	303593	249435	249021	
17	ITA	OTB	MDDWSP		VL1824			455880				
17	ITA	OTB	MDDWSP		VL2440			101556	85117	81784	15108	
17	ITA	OTM	MDPSP		VL0612			666				
17	ITA	OTM	MDPSP		VL2440				963			
17	ITA	PS	SPF		VL0612		15395	11368				
17	ITA	PS	SPF		VL1218		1912	7297	13939	3958	1374	
17	ITA	PS	SPF		VL2440					15557		
17	ITA	PTM	SPF		VL1218		9255	28121	1056		11264	
17	ITA	PTM	SPF		VL1824		446896	309738	331008	393874	93255	
17	ITA	PTM	SPF		VL2440		170745	183571	198308	225578	385407	
17	ITA	TBB	DEMSP		VL1218		32478	16587	30023	74266	54618	
17	ITA	TBB	DEMSP		VL1824		229009	266268	365432	304104	172961	
17	ITA	TBB	DEMSP		VL2440		104553	93303	108658	138558	267487	
17	SVN	FPO	DEMSP	NA	VL0006			738	788	695	1124	382
17	SVN	FPO	DEMSP	NA	VL0012			846	788	695	1145	382
17	SVN	FPO	DEMSP	NA	VL0612			107			20	
17	SVN	FPO	DEMSP	NA	VL1218						6632	11027
17	SVN	FPO	DEMSP	NA	VL1224						6632	11027
17	SVN	FYK	DEMSP	NA	VL0006			165	495	637	18	458
17	SVN	FYK	DEMSP	NA	VL0012			165	554	637	18	458
17	SVN	FYK	DEMSP	NA	VL0612				59			
17	SVN	GND	SPF	20D40	VL0012			1135	227	92	219	141
17	SVN	GND	SPF	20D40	VL0612			1135	227	92	219	141
17	SVN	GND	SPF	20D40	VL1218					355		
17	SVN	GND	SPF	20D40	VL1224					355		
17	SVN	GNS	DEMSP	16D20	VL0006			3624	3368	4616	4970	6367
17	SVN	GNS	DEMSP	16D20	VL0012			20524	20108	20482	47601	53623
17	SVN	GNS	DEMSP	16D20	VL0612			16900	16739	15893	42671	47256
17	SVN	GNS	DEMSP	16D20	VL1218			67	996	8602	4938	861
17	SVN	GNS	DEMSP	16D20	VL1224			67	996	8602	4938	861
17	SVN	GTR	DEMSP	50D100	VL0006			2767	1608	3570	7475	6644
17	SVN	GTR	DEMSP	50D100	VL0012			29427	37010	75895	81751	78489
17	SVN	GTR	DEMSP	50D100	VL0612			26660	35402	72386	74276	71844
17	SVN	GTR	DEMSP	50D100	VL1218			15970		7548	5137	1387
17	SVN	GTR	DEMSP	50D100	VL1224			15970		7548	5137	1387
17	SVN	LHP-LHM	CEP	NA	VL0006							11
17	SVN	LHP-LHM	CEP	NA	VL0012						3	11
17	SVN	LHP-LHM	CEP	NA	VL0612						3	
17	SVN	LHP-LHM	FINF	NA	VL0006					4	3	9
17	SVN	LHP-LHM	FINF	NA	VL0012			10		4	20	12
17	SVN	LHP-LHM	FINF	NA	VL0612			10			17	4
17	SVN	LLS	DEMSP	NA	VL0006			22	13	36	31	22
17	SVN	LLS	DEMSP	NA	VL0012			153	637	36	40	421
17	SVN	LLS	DEMSP	NA	VL0612			131	624		8	399
17	SVN	LLS	DEMSP	NA	VL1218					27		
17	SVN	LLS	DEMSP	NA	VL1224					27		
17	SVN	OTB	DEMSP	40D50	VL0006			17				4
17	SVN	OTB	DEMSP	40D50	VL0012			17615	19313	20311	18128	14912
17	SVN	OTB	DEMSP	40D50	VL0612			18935	27569	34965	37112	40305
17	SVN	OTB	DEMSP	40D50	VL1218			41539	54928	76356	79234	84796
17	SVN	OTB	DEMSP	40D50	VL1224			41539	54928	76356	79234	84796
17	SVN	OTB	DEMSP	40D50	VL2440					600	350	
17	SVN	OTM	MDPSP	20D40	VL1218						47	196
17	SVN	OTM	MDPSP	20D40	VL1224						47	196
17	SVN	OTM	MDPSP	20D40	VL2440							550
17	SVN	PS	SPF	14D16	VL0006							3
17	SVN	PS	SPF	14D16	VL0012			3169	4648	6209	4073	3009
17	SVN	PS	SPF	14D16	VL0612			3169	4648	6209	4073	3005
17	SVN	PS	SPF	14D16	VL1218			14080	15883	11865	12994	20598
17	SVN	PS	SPF	14D16	VL1224			14080	15883	11865	12994	20598
17	SVN	PTM	SPF	20D40	VL2440			100585	91719	110404	69808	102116

5.25.3. Scientific surveys

5.25.3.1. Medits

5.25.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 17 the following number of hauls was reported per depth stratum (s. Tab. 5.25.3.1.1.1).

Tab. 5.25.3.1.1.1. Number of hauls per year and depth stratum in GSA 17, 2002-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA17_010-050									57	45	47	61	49	52	51	49
GSA17_050-100									54	36	37	62	38	32	37	37
GSA17_100-200									50	27	22	43	21	24	23	22
GSA17_200-500									9	7	5	7	5	5	5	5
GSA17_500-800									1	1						

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length

frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.25.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.25.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 17 was derived from the international survey Medits. Figure 5.25.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 17. SGMED-10-02 notes that the biomass index in 2004 needs a verification.

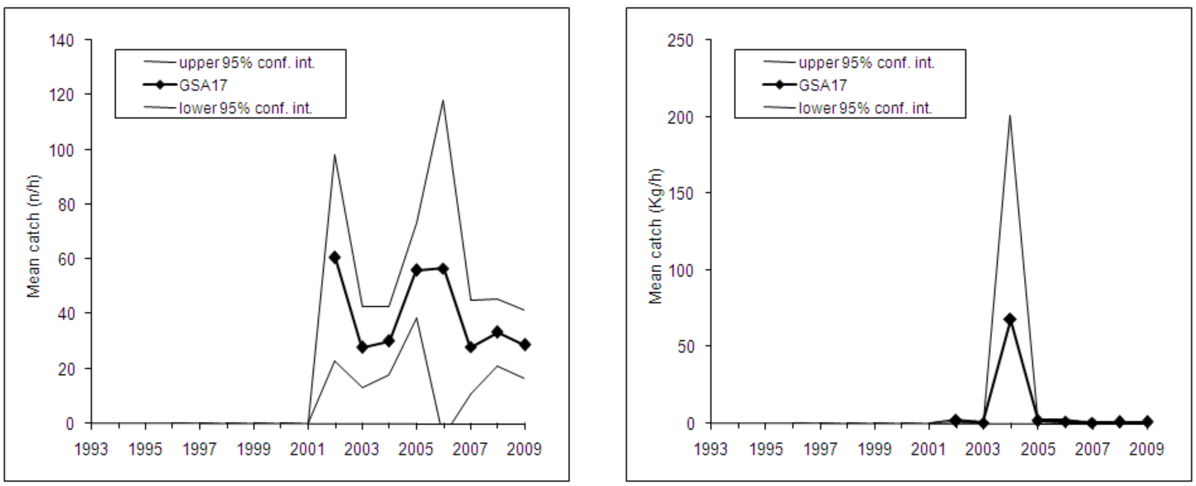


Fig. 5.25.3.1.3.1 Abundance and biomass indices of red mullet in GSA 17, 2002-2009.

5.25.3.1.4. Trends in abundance by length or age

The following Fig. 5.25.3.1.4.1 displays the stratified abundance indices of GSA 17 in 2002-2009.

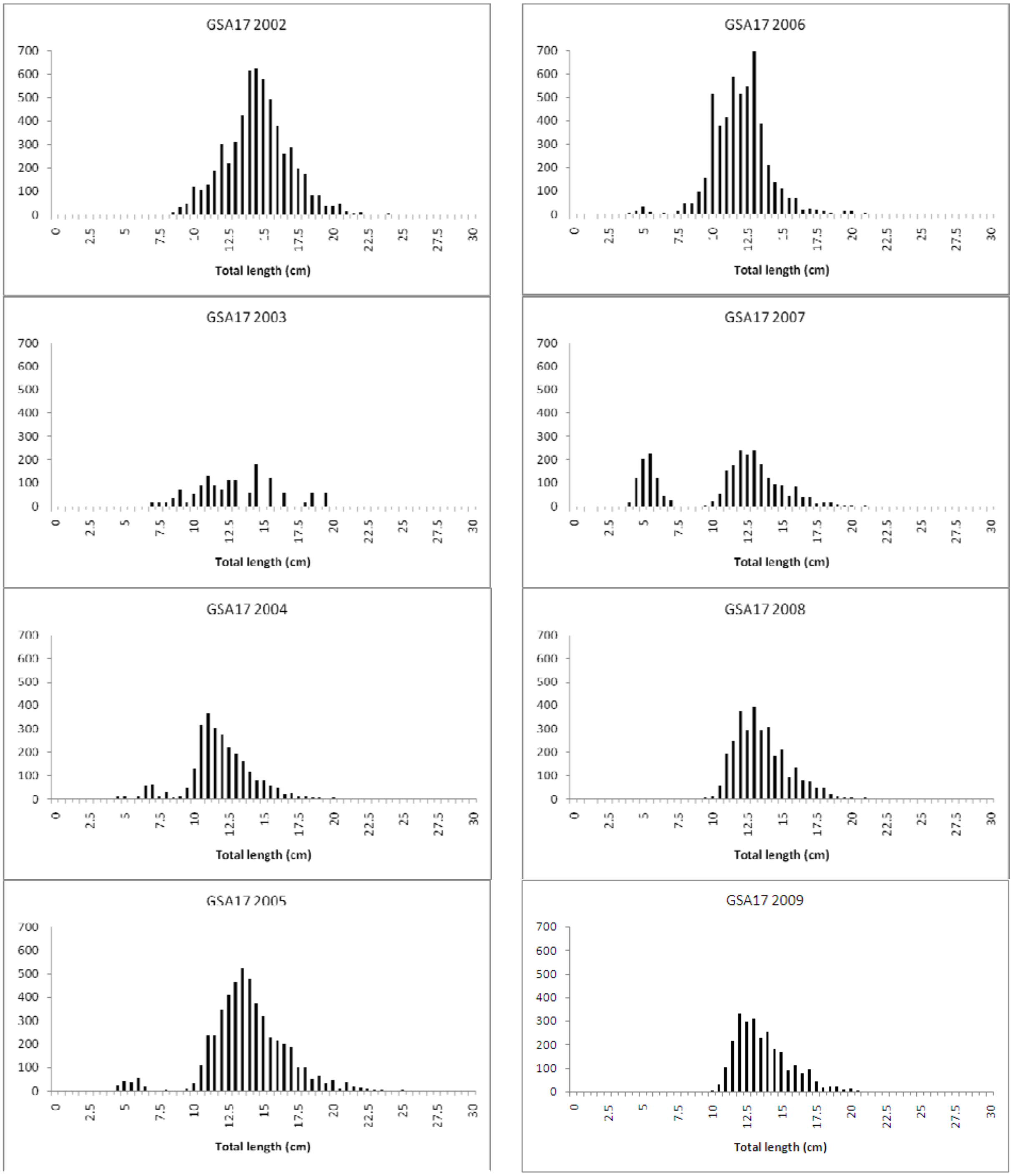


Fig. 8.24.3.1.4.1 Stratified abundance indices by size, 2002-2009.

5.25.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.25.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.25.4. Assessment of historic stock parameters

SGMED 10-02 did not undertake any analytical assessment of red mullet in GSA 17. Last year's assessment using LCA can be found in the report of SGMED-08-04 working group (Cardinale *et al.*, 2008).

5.25.5. Long term prediction

5.25.5.1. Justification

No forecast analyses were conducted.

5.25.5.2. Input parameters

No forecast analyses were conducted.

5.25.5.3. Results

SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for hake in GSA 17.

5.25.6. Scientific advice

5.25.6.1. Short term considerations

5.25.6.1.1. State of the spawning stock size

The average stock biomass estimated by LCA in 2006-2007 was around 4,000 tonnes. In the absence of any proposed or agreed management reference points, SGMED-10-02 cannot fully evaluate the state of the stock.

5.25.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.25.6.1.3. State of exploitation

In the absence an analytical assessment and any proposed or agreed target referenses, SGMED-10-02 cannot fully evaluate the state of the exploitation.

5.26. Stock assessment of red mullet in GSA 18

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.26.1. Stock identification and biological features

5.26.1.1. Stock Identification

The stock of red mullet is defined within the boundaries of the whole GSA 18. Genetic studies conducted in the Adriatic (Garoia *et al*., 2004) evidenced that samples were characterised by high genetic diversity, but the spatial genetic heterogeneity was not related to a geographic cline. However, the randomness of genetic differences among samples indicated that the Adriatic red mullet stock probably belongs to a single population unit. Nevertheless, individuals may group into local, genetically differentiated sub-populations. The observed genetic fragmentation in the Adriatic stock might be due to reproductive success, survival rates or fishing pressure.

In addition to the genetic considerations, indications agreed upon by SGMED/ECA/RST-09-01 and based on correlation matrices of trawl-survey data in adjacent areas suggested a more geographically localised pattern for the distribution of red mullet.

In the Adriatic Sea red mullet spawns in late spring and summer and according to Haidar (1970) the most intensive spawning occurs at depths of 60 to 70 m. After spawning, post larvae move towards shallower water (30-40 m) and then towards sandy coastal areas to become demersal at 4 cm TL. Later, they start their dispersion in deeper waters towards sandy, muddy and gravel grounds (Relini *et al.*, 1999). Regarding the sex ratio males are generally prevailing up to 14-15 cm, while females are more frequent over 15-16 cm TL. The relative index of the population abundance is observed to decrease with depth. According to Haidar (1970) the main fish predators of juvenile and adult red mullet are *Lophius piscatorius*, *Raja clavata*, *Zeus faber* and *Merluccius merluccius*.

5.26.1.2. Growth

Literature data on the growth of red mullet in the Adriatic Sea are very variable (AdriaMed website). Asymptotic length for sex combined varies from 19.7 to 31.5 cm (range for females and males respectively: 26.2-34.5 cm; 17.8-27 cm), while the curvature parameter ranges for females and males respectively 0.122-0.23 and 0.184-0.282. According to Jardas (1996), red mullet grows up to about 30 cm (about 0.5 kg), although the usual total length in catches is from 10 to 20 cm. On average, females have greater body length than males and grow faster, which can be already noticed in the first year of their life (Haidar, 1970). Therefore, almost all largest specimens are females.

According to Scaccini (1947) the life cycle is 8 years with a faster growth rate in the first three years for both sexes, after a slower pattern is evidenced (y1=12.6-12.7 cm for males and females respectively, y2=17.5-20.3; y3=20.4-23.9; y8=25.5-29.3 cm). The estimated VBGF for sex combined from Scaccini (1947) were: L_∞=27.5 cm; K=0.5; t_0= -0.25. The growth parameters estimated by sex in the central-northern Adriatic area during the SAMED project (SAMED, 2002), using the analysis of length frequency distributions of MEDITS data, were: females: L_∞=27 cm; K=0.396; t_0= -0.78; males: L_∞=23 cm; K=0.43; t_0= -0.80.

Estimates of growth parameters were achieved using otolith data collected within the DCR framework. The following von Bertalanffy parameters were estimated for sex combined: L_∞=26.3 cm; K=0.45; t_0= -0.3.

Parameters of the length-weight relationship reported in literature for sex combined are a=0.008-0.0125, b=3.09-2.97 (Marano et al., 1994; 1998; Marano, 1996).

The parameters estimated within the DCR for sex combined were: a=0.0122, b=2.94; for females: a=0.017, b=2.85; and for males a=0.0169, b=2.85.

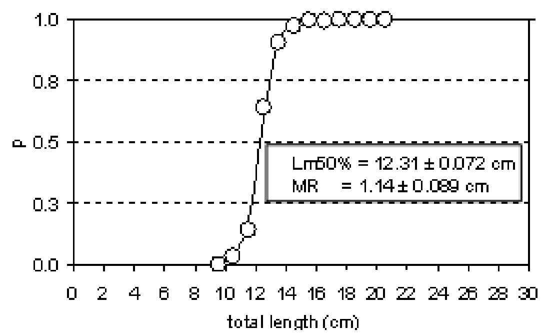
5.26.1.3. Maturity

According to Haidar (1970) females always have an annual reproduction cycle and reach sexual maturity in the first year of life at lengths around 12 cm. According to other literature data the size at first maturity for females is in the range 10-14 cm (AdriaMed website).

According to the data obtained in the DCR, the proportion of mature females (specimens belonging to the maturity stage 2 onwards) by length class is reported in the table below together with the maturity ogive estimated by a maximum likelihood procedure which indicates a $L_{m50\%}$ of about 12.3 cm (±0.072 cm) and a maturity range ($MR=L_{m75\%}-L_{m25\%}$) of 1.14±0.089 cm.

Tab. 5.26.1.3.1 and Fig. 5.26.1.3.1 Female maturity ogive (MR indicates the difference Lm75%-Lm25%).

CL (cm)	Proportion of mature females
9	0
10	0.032
11	0.141
12	0.642
13	0.906
14	0.976
15	0.996
16	0.995
17	1
18	1
19	1
20	1



The sex ratio from DCR evidenced the prevalence of males in the size class from 9 to 15 cm and from 16 cm onwards the proportion of females was dominant.

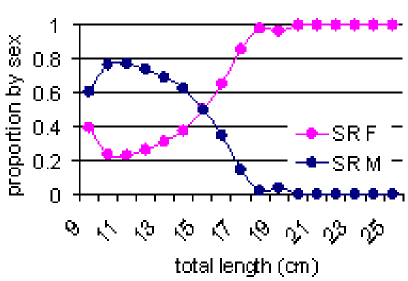


Fig. 5.26.1.3.2 Sex ratio at length for red mullet in GSA 18.

5.26.2. Fisheries

5.26.2.1. General description of fisheries

Red mullet is targeted by trawlers but also by small scale fisheries using gillnets and trammel nets. Fishing grounds are located along the coasts of the whole GSA. In the period from 1989 to 1994, the CPUE in the southern Adriatic was from 0.33 to 2.45 kg/h (EC XIV/298/96-EN, 1996). Red mullet co-occurs with other important commercial species as *Pagellus* sp., *Eledone* sp., *Octopus* sp., *M. merluccius*.

5.26.2.2. Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures, like the number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of the fleet, the Italian fishing licenses have been fixed since the late 1980s. After 2000, in agreement with the European Common Fisheries Policy, a gradual decreasing of the fleet capacity is implemented. Two closed areas were also established in 2004 along the mainland, in front of Bari and in the vicinity of Tremiti MPA on the northernmost part of the GSA. Other measures are mesh size, minimum landing sizes and the minimum distance (or depth) from the coastline (EC Reg. 1967/06). In the GSA 18 the fishing ban has been almost always mandatory since 1988 for a period of 30-45 days, generally during late July-early September.

5.26.2.3. Catches

5.26.2.3.1. Landings

Available landing data are from DCF regulations. SGMED-10-02 received Italian landings data for GSA 18 by major fishing gears which are listed in Tab. 5.26.2.3.1.1, but not for 2009. Trawlers account for the majority of the landings. The low figure of OTB MDDWSP in 2008 needs to be verified.

Tab. 5.26.2.3.1.1. Annual landings (t) of red mullet in GSA 18, by major gear type, 2004-2008.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	18	ITA								1	0		
MUT	18	ITA	GNS	DEMSP				82	99	123	120	42	
MUT	18	ITA	GNS	SLPF								0	
MUT	18	ITA	GTR	DEMSP						6	3	5	
MUT	18	ITA	LLS	DEMF					0				
MUT	18	ITA	OTB	DEMSP				689	154	383	560	892	
MUT	18	ITA	OTB	DWSP								0	
MUT	18	ITA	OTB	MDDWSP				1292	1196	1420	1120	22	
MUT	18	ITA	PTM	SPF				0					
Sum								2063	1449	1933	1803	961	

5.26.2.3.2. Discards

No information was documented.

5.26.2.3.3. Fishing effort

Available fishing effort data are from DCF, but not for 2009. The trends in fishing effort by year and major gear type is listed in Tab. 5.26.2.3.3.1.

Tab. 5.26.2.3.3.1. Trend in fishing effort (kW*days) in the GSA 18, 2004-2008.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
18	ITA				VL0006						653	
18	ITA				VL1218				18973			
18	ITA	DRB	MOL		VL1218		31755	15206	60312	29038	24106	
18	ITA	GNS	DEMSP		VL0006				0	0	0	
18	ITA	GNS	DEMSP		VL0612		79455	107014	73603	59052	76376	
18	ITA	GNS	DEMSP		VL1218				11360			
18	ITA	GTR	DEMSP		VL0006				0	767	3639	
18	ITA	GTR	DEMSP		VL0612		9276	16931	947		48849	
18	ITA	LHP-LHM	CEP		VL0006						1115	
18	ITA	LHP-LHM	CEP		VL0612				0			
18	ITA	LLD	LPF		VL0006						1453	
18	ITA	LLD	LPF		VL0612				0		1686	
18	ITA	LLD	LPF		VL1218			4999		3454		
18	ITA	LLS	DEMF		VL0006				1031	0	731	
18	ITA	LLS	DEMF		VL0612		2168	8862	8103	21686	24959	
18	ITA	LLS	DEMF		VL1218			4999	7077	43626	84915	
18	ITA	OTB	DEMSP		VL0612		31970	31096	30666	13651	27993	
18	ITA	OTB	DEMSP		VL1218				566531		485808	
18	ITA	OTB	DEMSP		VL1824						182427	
18	ITA	OTB	DEMSP		VL2440		36432				122656	
18	ITA	OTB	MDDWSP		VL0612		1409					
18	ITA	OTB	MDDWSP		VL1218		426469	539707		486560	49978	
18	ITA	OTB	MDDWSP		VL1824		390285	349132	553919	455935	44323	
18	ITA	OTB	MDDWSP		VL2440		339413	244695	123388	144908	4025	
18	ITA	PS	SPF		VL2440					27636	10183	
18	ITA	PTM	SPF		VL2440		74992	112819	141218	191256	128292	

5.26.3. Scientific surveys

5.26.3.1. Medits

5.26.3.1.1. Methods

Trawl surveys were carried out applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area (Bertrand et al., 2002). The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed.

Based on the DCF data call, abundance and biomass indices were calculated. In GSA 18 the following numbers of hauls were reported per depth stratum (Tab. 5.26.3.1.1.1).

Tab. 5.26.3.1.1.1. Number of hauls per year and depth stratum in GSA 18, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA18_010-050	14	15	15	14	14	14	14	15	13	13	12	9	10	11	10	10
GSA18_050-100	14	14	14	15	15	15	15	14	21	21	23	16	15	15	14	13
GSA18_100-200	24	23	23	23	23	23	23	23	34	31	32	25	25	23	22	25
GSA18_200-500	10	10	10	10	10	10	10	10	15	15	16	10	10	9	8	11
GSA18_500-800	10	10	10	10	10	10	10	10	14	14	14	7	7	7	5	6

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Only hauls considered valid were used, including stations with no catches of red mullet (zero catches are included).

The abundance and biomass indices were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval:
Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.26.3.1.2. Geographical distribution patterns

The geographical distribution pattern of red mullet in the GSA 18 has been studied using trawl-survey data and geostatistical methods. In these studies the abundance indices of recruits were analysed. Results highlighted a patchy distribution of red mullet juveniles mostly concentrated along the coast of the South Adriatic Sea within 50 m of depth. The areas showing the highest probability and persistency were detected from 1997 to 2002 using cut-offs of 5000 and 10000 N/km^2. In particular, the nursery areas distributed along the Gargano peninsula and along the coasts off the area between Molfetta and Brindisi were observed with a probability up to 0.8, within 50 m of depth. Mapping of the red mullet nursery obtained applying the median indicator kriging technique are reported below.

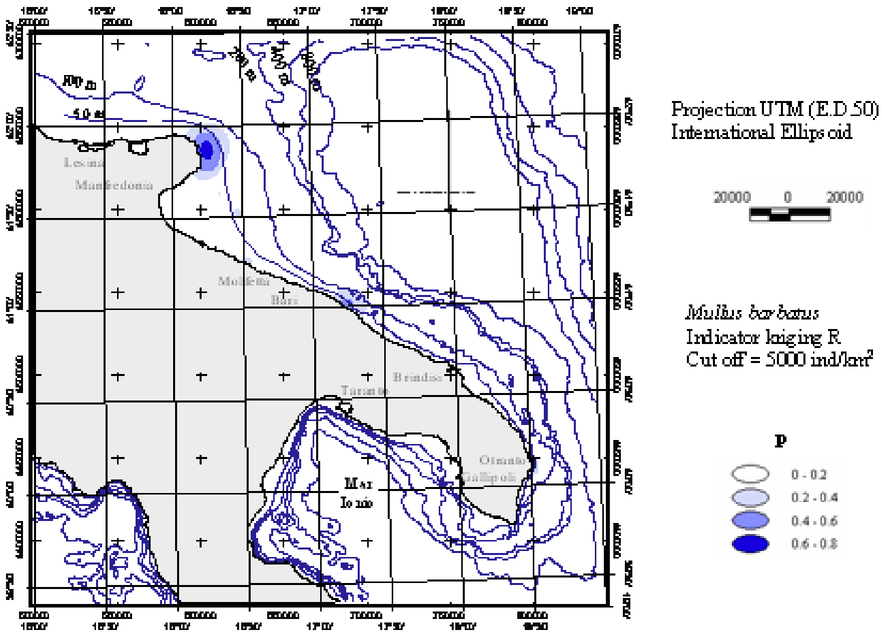


Fig. 5.26.3.1.2.1 Geographical distribution patterns.

5.26.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in the GSA 18 was derived from the international survey Medits. Figure 5.26.3.1.3.1 displays the estimated trend of red mullet abundance and biomass in GSA 18. Abundance and biomass indices show high interannual variations without a clear trend. However, estimated biomass indices appear at an increased level since 1999.

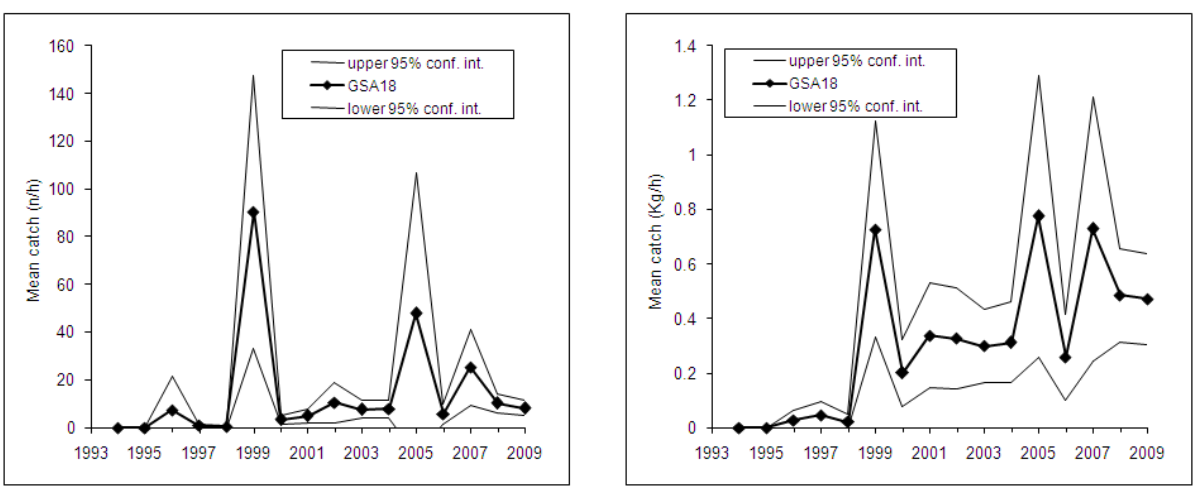


Fig. 5.26.3.1.3.1 Abundance and biomass indices of red mullet in GSA 18.

5.26.3.1.4. Trends in abundance by length or age

The following Fig. 5.26.3.1.4.1 and 2 display the stratified abundance indices of GSA 18 in 1994-2001 and 2002-2009.

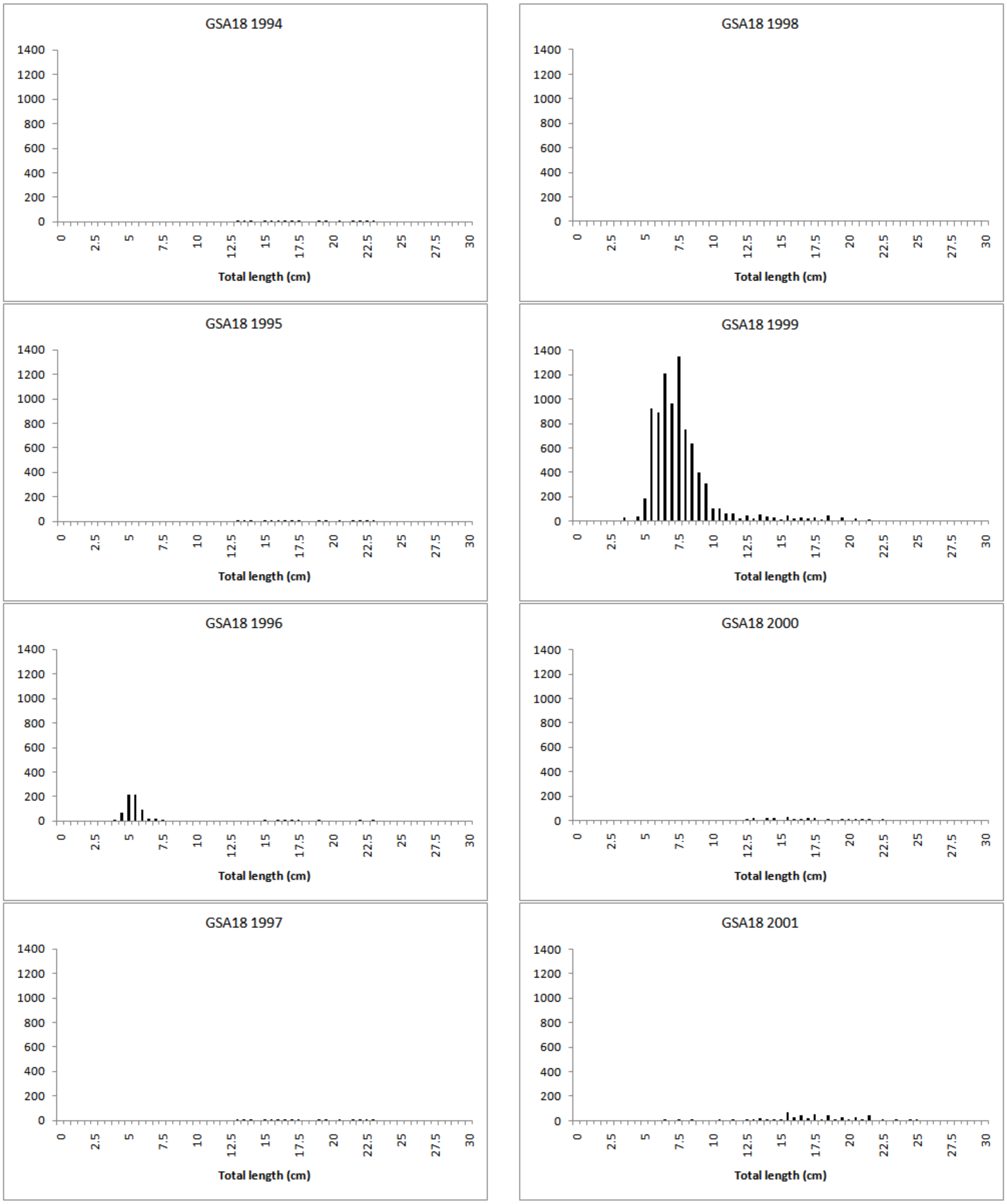


Fig. 5.26.3.1.4.1 Stratified abundance indices by size, 1994-2001.

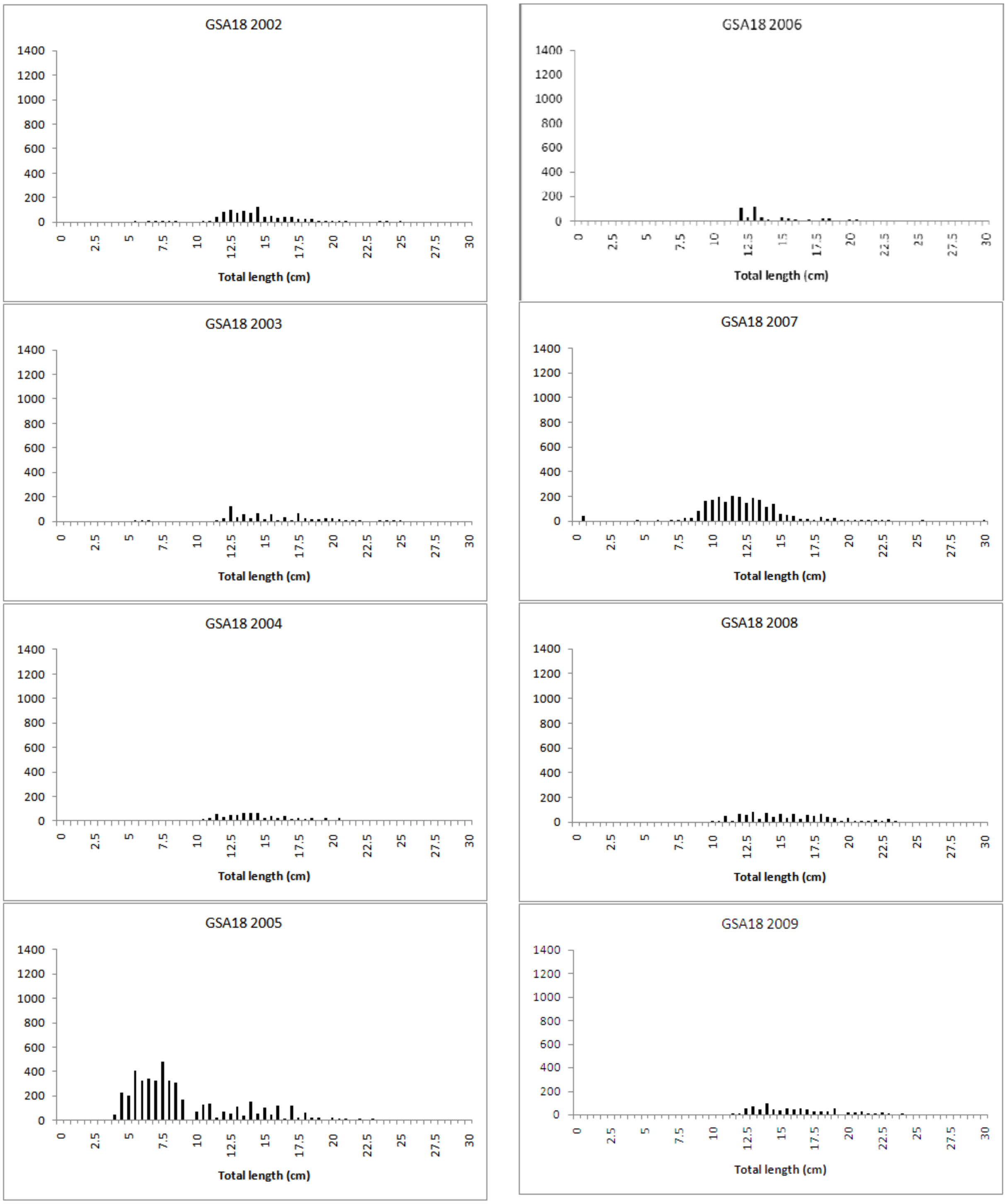


Fig. 5.26.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.26.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.26.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.26.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.26.5. Long term prediction

5.26.5.1. Justification

No forecast analyses were conducted.

5.26.5.2. Input parameters

No forecast analyses were conducted.

5.26.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for red mullet in GSA 18.

5.26.6. Scientific advice

5.26.6.1. Short term considerations

5.26.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.26.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.26.6.1.3. State of exploitation

The lack of an analytical assessment and proposed or agreed management reference points prevents SGMED-10-02 to provide any scientific advice of the state of the exploitation.

5.27. Stock assessment of red mullet in GSA 19

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.27.1. Stock identification and biological features

5.27.1.1. Stock Identification

No information was documented.

5.27.1.2. Growth

The data provided during the meeting refer to von Bertalanffy parameters estimates, and are presented in the following table. The growth parameters agreed for red mullet in other areas are comprised between 25 and 27 cm for L(inf) and 0.3 and 0.5 for K (with negative correlation between both). Considering also other growth parameter estimates and that the maximum length is 24 cm, the following growth parameters have been adopted for assessment: L(inf)=6, K=0.3 and t_0=-1.0. With similar criteria the length-weight relationship are a= 0.007 and b=3.17.

Table 5.27.1.2.1 Growth parameters and methods applied.

COUNTRY	GSA	YEAR_PERIOD	SPECIES	SEX	L_INF	K	T0	A	B	METHOD_USED
ITA	19	2003-2005	MUT	F	27.5	0.35	-0.9	0.0068	3.1	otoliths reading
ITA	19	2008	MUT	F				0.005	3.2	
ITA	19	2002-2005	MUT	F	24.5	0.27	-1.9	0.0072	3.2	otoliths reading
ITA	19	2003-2005	MUT	M	20.3	0.6	-0.6	0.0102	3.1	otoliths reading
ITA	19	2008	MUT	M				0.006	3.2	
ITA	19	2002-2005	MUT	M	22.4	0.28	-2	0.009	3.1	otoliths reading
ITA	19	2003-2005	MUT	C				0.0063	3.21	
ITA	19	2008	MUT	C				0.0055	3.2	

5.27.1.3. Maturity

Data available during SGMED-10-02 allow to estimate the maturity ogives, for males and females separately for 2008 and compare them with females in the period 2002-2005. It appears that the length at first maturity (L50%) for females has increased from 10.5 to 11.75 cm.

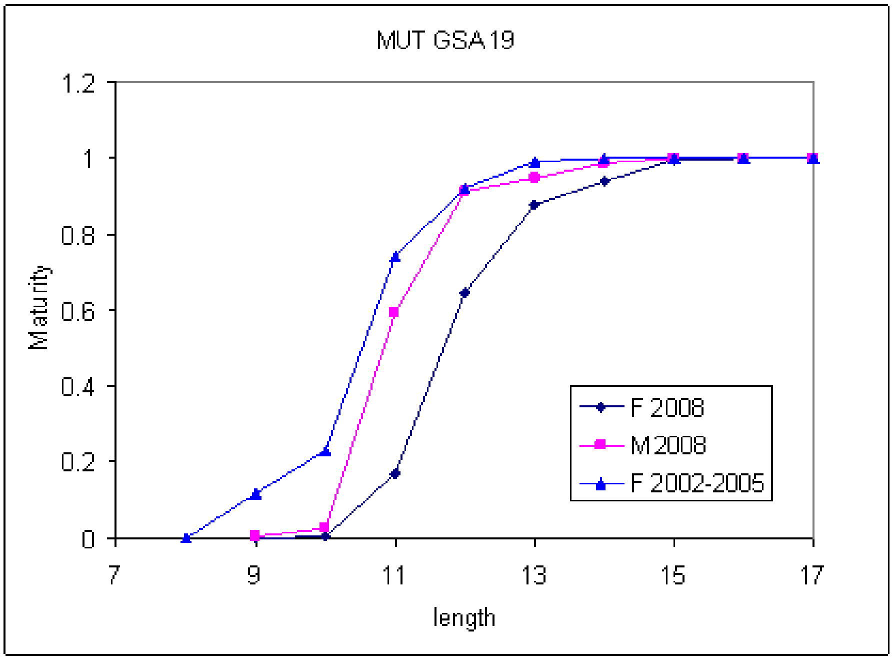


Fig. 5.27.1.3.1 Maturity ogives by sex and years.

Individuals larger than 19 cm are all females, implying sexual dimorphism regarding growth, with the asymptotic length of females larger than males (probably associated with differential natural mortality).

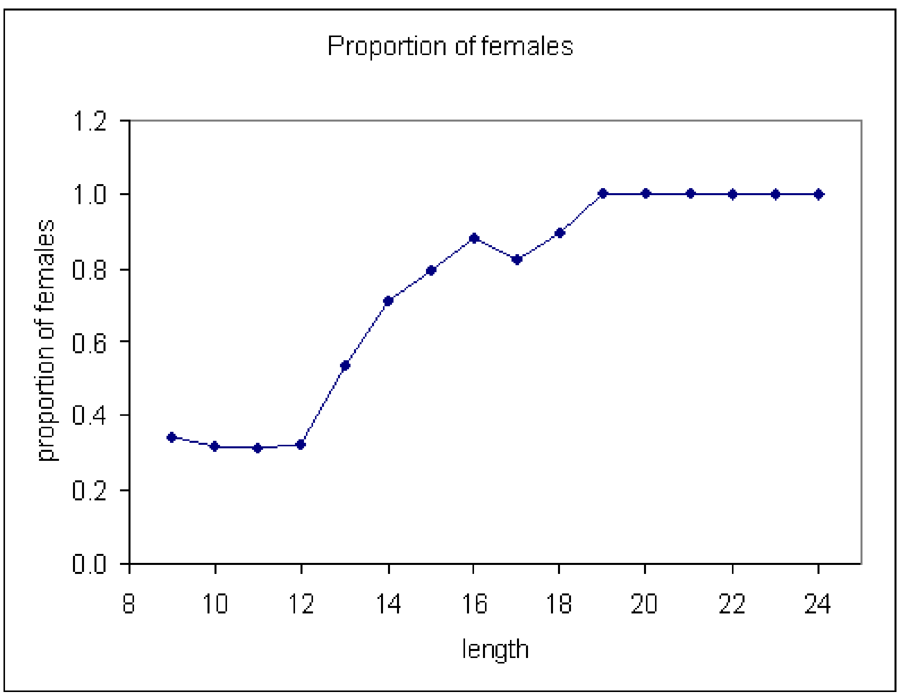


Fig. 5.27.1.3.2 Female maturity ogive.

5.27.2. Fisheries

5.27.2.1. General description of fisheries

STECF in 2009 (stock review part II) *Mullus barbatus* is among the species with high commercial value. The highest trawl fishing pressure occurs along the Calabrian coast while the presence of rocky bottoms on the shelf along the Apulian coast prevents fishing by trawling in this sector. The landings in the 2004 in the whole GSA 19 were detected around 321 t coming mainly from bottom trawling and small-scale boats.

5.27.2.2. Management regulations applicable in 2009 and 2010

No information was documented.

5.27.2.3. Catches

5.27.2.3.1. Landings

Tab. 5.27.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Framework Regulation. Since 2005 the annual landings decreased from 1,114 t to only 449 t in 2008. Many gears contributed to the reported landings. No data were reported for 2009.

Tab. 5.27.2.3.1.1. Annual landings (t) by fishing technique in GSA 19, 2004-2008.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	19	ITA						0	0		1	1	
MUT	19	ITA	GNS	DEMSP				52	43	65	55	69	
MUT	19	ITA	GNS	SLPF							0		
MUT	19	ITA	GTR	DEMSP				535	760	241	190	29	
MUT	19	ITA	LLD	LPF								0	
MUT	19	ITA	LLS	DEMF				0				1	
MUT	19	ITA	OTB	DEMSP				116	15	39	16	217	
MUT	19	ITA	OTB	DWSP							23	5	
MUT	19	ITA	OTB	MDDWSP				248	283	527	248	127	
MUT	19	ITA	PS	LPF					0				
MUT	19	ITA	PS	SPF					1				
MUT	19	ITA	PTM	SPF						0			
MUT	19	ITA	SB-SV	DEMSP				0	12	15	8	0	
Sum								951	1114	887	541	449	

5.27.2.3.2. Discards

7 t of discards in 2005 were reported through the DCR data call.

5.27.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Table 5.27.2.3.3.1.

Tab. 5.27.2.3.3.1 Trends in annual fishing effort by fishing technique deployed in GSA 19, 2004-2008. No data provided for 2009.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
19	ITA				VL0006				0	1589	1289	
19	ITA				VL0612		43727	21997	57851	74979	39123	
19	ITA				VL1218		9424	43715	40060	28934	51895	
19	ITA	FPO	DEMSP		VL0612		25169	2690	3229	4066	4330	
19	ITA	FPO	DEMSP		VL1218		8894				52399	
19	ITA	GND	SPF		VL0006				0	0		
19	ITA	GND	SPF		VL0612		60866		4327	14947	13293	
19	ITA	GND	SPF		VL1218				6437	33090		
19	ITA	GNS	DEMSP		VL0006				0	2317	2514	
19	ITA	GNS	DEMSP		VL0612		42380	52151	52916	116463	56469	
19	ITA	GNS	DEMSP		VL1218		19276	5898	8441		3077	
19	ITA	GTR	DEMSP		VL0006				1576	0	3994	
19	ITA	GTR	DEMSP		VL0612		93233	21618	28909	49607	73983	
19	ITA	GTR	DEMSP		VL1218		37514		9694	22498	33993	
19	ITA	LHP-LHM	CEP		VL0612		0	0			901	
19	ITA	LLD	LPF		VL0006				0	0		
19	ITA	LLD	LPF		VL0612		21059	2262			1613	
19	ITA	LLD	LPF		VL1218		24556	11063		49548	86997	
19	ITA	LLD	LPF		VL1824		130836	29278	87254	162415	221621	
19	ITA	LLS	DEMF		VL0006				0	335	281	
19	ITA	LLS	DEMF		VL0612		32056	17304	941	31232	31930	
19	ITA	LLS	DEMF		VL1218		6788	25928	12992	30438	38940	
19	ITA	LLS	DEMF		VL1824		9101					
19	ITA	LTL	LPF		VL0612				2903			
19	ITA	OTB	DEMSP		VL1218		20694	128112			171458	
19	ITA	OTB	DEMSP		VL1824		45169				18603	
19	ITA	OTB	DWSP		VL1218					57896		
19	ITA	OTB	MDDWSP		VL1218		246735	207953	386565	396114	254049	
19	ITA	OTB	MDDWSP		VL1824		24687	97647	28684	44800	37335	
19	ITA	PS	LPF		VL1218				5610			
19	ITA	PS	SPF		VL0612			28041			6985	
19	ITA	PS	SPF		VL1218		94936		9833	49469	43538	
19	ITA	SB-SV	DEMSP		VL0612		17636					
19	ITA	SB-SV	DEMSP		VL1218		7479		25107		2220	
19	ITA	SB-SV	DEMSP		VL1824		33305					

5.27.3. Scientific surveys

5.27.3.1. MEDITS

5.27.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 19 the following number of hauls were reported per depth stratum (s. Tab. 5.27.3.1.1.1).

Tab. 5.27.3.1.1.1. Number of hauls per year and depth stratum in GSA 19, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA19_010-050	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9
GSA19_050-100	7	8	8	8	8	8	8	8	8	8	8	8	8	9	8	8
GSA19_100-200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	10
GSA19_200-500	16	15	15	15	15	15	15	15	21	21	14	15	14	14	14	14
GSA19_500-800	31	32	32	32	32	32	32	32	29	29	29	28	29	29	29	30

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

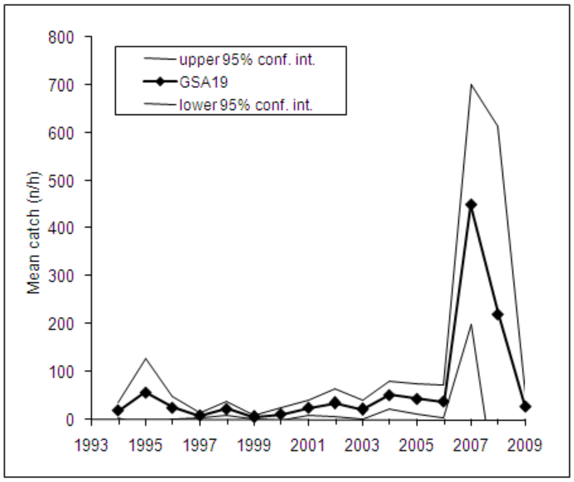
5.27.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.27.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 19 was derived from the international survey Medits. Figure 5.27.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 19.

The estimated abundance and biomass indices do not reveal any significant trends during 1994-2006. However, the recent abundance and biomass indices in 2007 and 2008 represent the highest values observed in the time series but are subject to high variation.



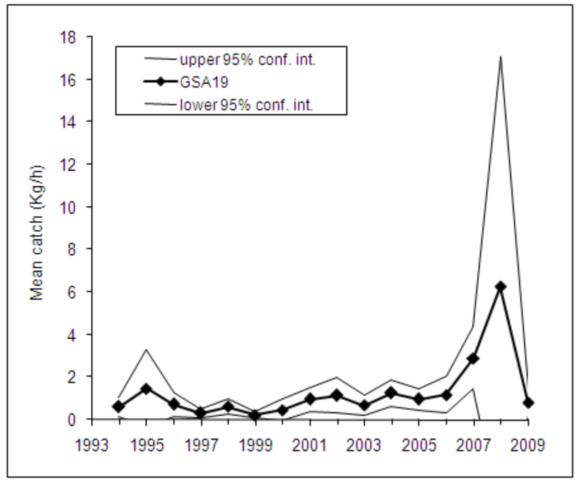


Fig. 5.27.3.1.3.1 Abundance and biomass indices of red mullet in GSA 19.

5.27.3.1.4. Trends in abundance by length or age

The following Fig. 5.27.3.1.4.1 and 2 display the stratified abundance indices of GSA 19 in 1994-2001 and 2002-2009, respectively.

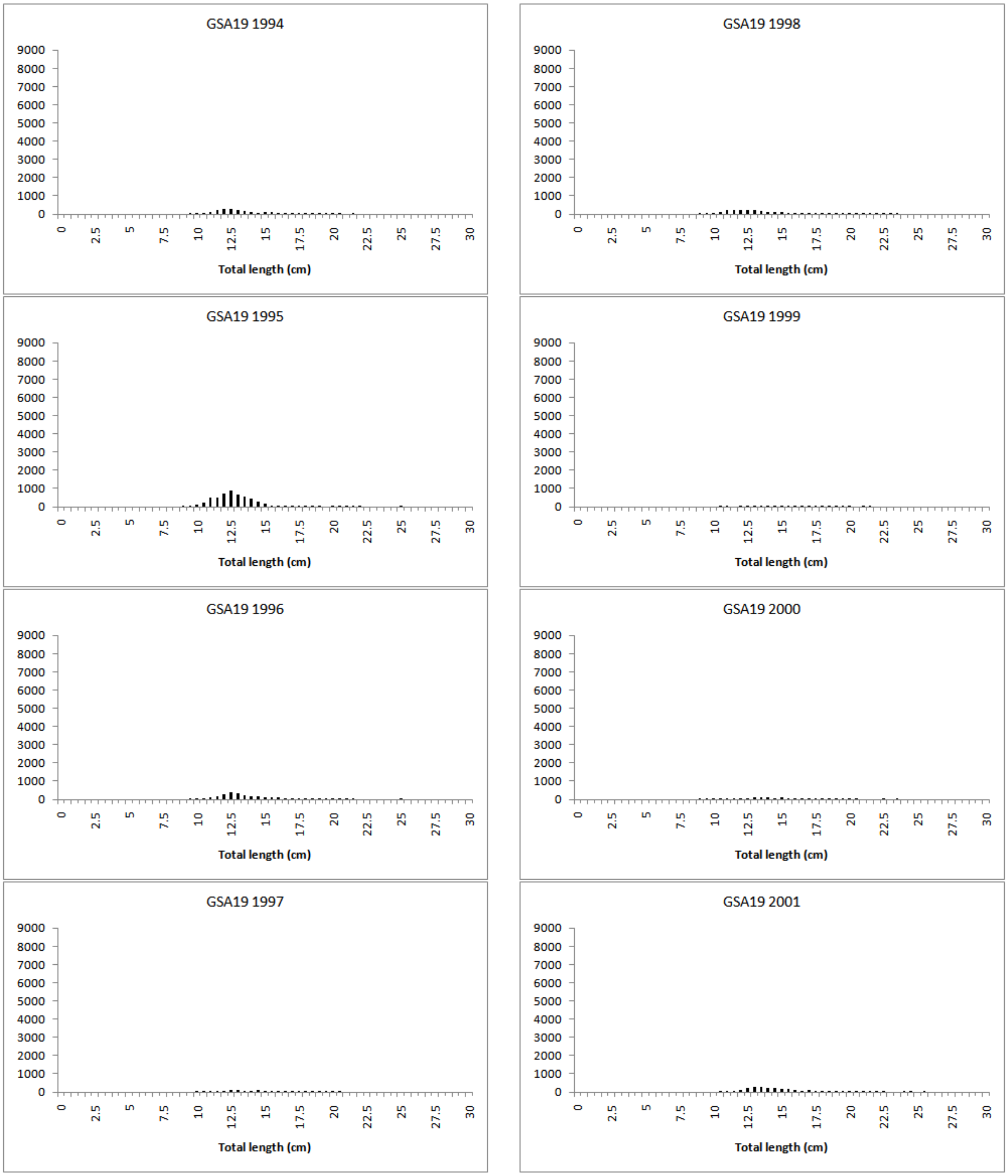


Fig. 5.27.3.1.4.1 Stratified abundance indices by size, 1994-2001.

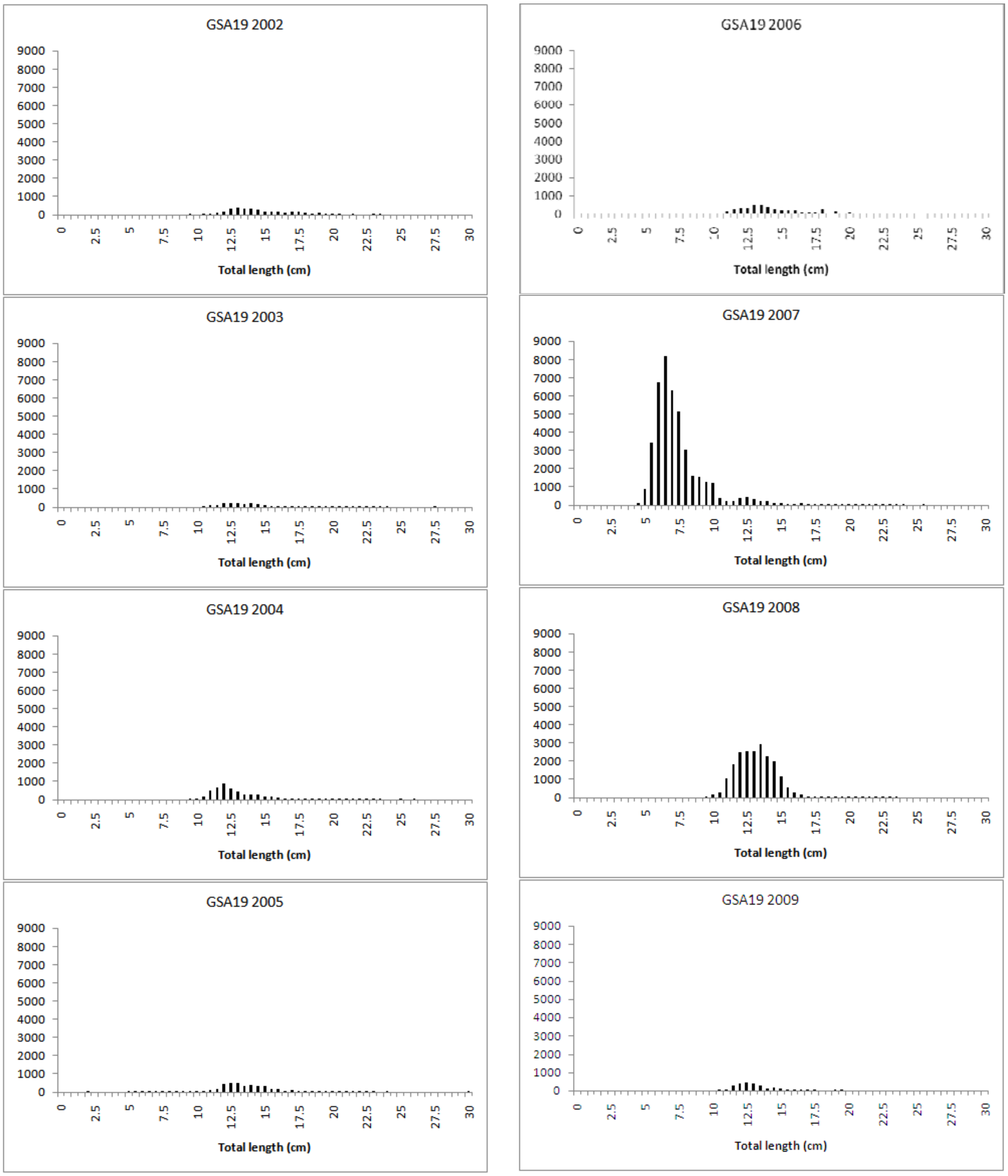


Fig. 5.27.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.27.3.1.5. Trends in growth

No analyses were conducted.

5.27.3.1.6. Trends in maturity

No analyses were conducted.

5.27.4. *Assessment of historic stock parameters*

The most recent analytical assessment was done by SGMED-09-02 and is documented in that report (Cardinale et al., 2009).

5.27.5. *Long term prediction*

5.27.5.1. Justification

No analyses conducted by SGMED-10-02.

5.27.5.2. Input parameters

No analyses conducted by SGMED-10-02.

5.27.5.3. Results

No analyses conducted by SGMED-10-02.

5.27.6. *Scientific advice*

5.27.6.1. Short term considerations

5.27.6.1.1. State of the spawning stock size

Survey indices show significant abundance increases in 2007 and 2008. SGMED-10-02 is unable to fully evalute the stock status due to a lack of proposed or agreed precautionary management reference points.

5.27.6.1.2. State of recruitment

SGMED-10-02 notes that the recruitment in 2007 was exceptionally high resulting in stock size increases in 2007 and 2008.

5.27.6.1.3. State of exploitation

In the absence of an updated analytical assessment and proposed or agreed management reference points of the exploitation status SGMED-10-02 is unable to fully evalute the stock status.

5.28. Stock assessment of red mullet in GSA 20

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.28.1. Stock identification and biological features

5.28.1.1. Stock Identification

Red mullet is one of the most common and most valuable fish species in Greek Seas. The species is fished by bottom trawl and nets (mainly gill nets) in shallow-mid waters along the Greek coasts. The stock is distributed mainly on muddy bottoms along the coast. Its depth distribution is limited in depths less than 200 m. However, is not abundant in water deeper than 150 m. Spawning takes place during spring-early summer. The juveniles of the species are concentrated in shallow waters (10-50 m). Nursery grounds in GSA 20 have been defined along the Western Coast of Peloponnese and Epirus. The stock in GSA 20 is exploited exclusively by the Greek fleet.

5.28.1.2. Growth

No information was documented during SGMED-10-02.

5.28.1.3. Maturity

No information was documented during SGMED-10-02.

5.28.2. Fisheries

5.28.2.1. General description of fisheries

The main fishing gears targeting red mullet in GSA 20 are bottom trawls and gill nets. In some cases, trammel nets are used as well. According to the European and Greek Legislation, bottom trawls operate in waters deeper than 50 m or in a distance 3 miles from the coasts. Thus the gear is targeting the species in waters from the limit (as defined by the legislation) down to 150 m (or deeper but the abundance is not high so red mullet is not the target or one of the target species). Illegal fishing by bottom trawls was very common in the past (in waters less than 50 m or in a distance less than 3 miles) and could be considered as harmful for the species. Large quantities of 0 age specimens, with length 5-9 cm, were caught during autumn. Nowadays, with the use of VMS the situation has been improved significantly but the problem still exists.

There is no depth limit or restriction related to distance from shore for the nets in Greece. However, nets from October to May usually fish at depths <50 m or in a distance <3 miles from the coasts. During summer, when bottom trawl fishery is closed, nets may be used in deeper waters. The mesh size is usually 36-44 mm but there are cases where smaller mesh size (32 or 34 mm) is used. Mesh sizes >36 mm have no important impact on the juveniles. The optimum selection lengths were at 13.5 cm, 15 cm, 16.5 cm and 17 cm for the 34 mm, 38 mm, 42 mm and 44 mm nets respectively (Petrakis, 1998). There is a clear seasonal pattern of the red mullet net metier, which varies between different areas depending on the abundance of the species and on the availability of other more profitable resources.

5.28.2.2. Management regulations applicable in 2009 and 2010

No specific regulation to manage the species is enforced. The MLS is 11 cm (according to EE 1967/2006 regulation).

5.28.2.3. Catches

5.28.2.3.1. Landings

Landings of red mullet in GSA 20 for the years 2003-2008 are presented in Tab. 5.28.2.3.1.1. No data updates were provided by the Greek authorities.

Tab. 5.28.2.3.1.1 Annual landings (t) by fishing technique as reported through the DCR data call, 2003-2008.

SPECIES	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
MUT	20	GRC	GTR		2104	728	514	432		654
MUT	20	GRC	OTB		164	180	226	154		406
MUT	20	GRC	SB		87	28	37	24		39

5.28.2.3.2. Discards

No discards data were reported to SGMED-10-02 through the DCF data call for Greece.

5.28.2.3.3. Fishing effort

Tab. 5.28.2.3.3.1 lists the effort by fishing technique deployed in GSA 20 as reported to SGMED-09-02 through the DCR data call. No data updates were reported by the Greek authorities. A decrease is observed for the main fleet using gill nets.

Tab. 5.28.2.3.3.1 Effort trends by fishing technique deployed in GSA 20, 2003-2008.

TYPE	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DAYS	20	GRC	GTR		838891	749522	777934	688042		574268
DAYS	20	GRC	LLS		1212	6333	3843	11810		99755
DAYS	20	GRC	OTB		7810	7296	6279	6682		6753
DAYS	20	GRC	PS		5386	4646	6132	5559		5197
DAYS	20	GRC	SB		13429	11118	10883	11363		12774
GT*DAYS	20	GRC	GTR		3338474	2974825	2949967	2509455		2264227
GT*DAYS	20	GRC	LLS		9110	43698	26517	81492		396520
GT*DAYS	20	GRC	OTB		574443	580133	435054	565011		534692
GT*DAYS	20	GRC	PS		105429	123580	230265	189582		155249
GT*DAYS	20	GRC	SB		83099	65507	58441	57058		75249
KW*DAYS	20	GRC	GTR		33001422	25547517	24809229	19460968		18504513
KW*DAYS	20	GRC	LLS		125676	698284	423729	1302215		3486777
KW*DAYS	20	GRC	OTB		2374841	2359179	1729664	2024955		1800736
KW*DAYS	20	GRC	PS		725384	874064	747375	626335		615159
KW*DAYS	20	GRC	SB		863066	697644	604098	623628		807597

5.28.3. Scientific surveys

5.28.3.1. Medits

5.28.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were calculated. In GSA 20 the following number of hauls was reported per depth stratum (s. Tab. 5.28.3.1.1.1). No survey was conducted in 2009.

Tab. 8.28.3.1.1.1. Number of hauls per year and depth stratum in GSA 20, 1994-2008.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GSA20_010-050	2	2	2	2	4	4	3	3		3	3	3	3		3
GSA20_050-100	3	4	8	7	11	10	11	10		10	10	10	9		10
GSA20_100-200	2	3	4	2	5	6	5	6		6	6	5	6		6
GSA20_200-500	2	3	4	4	7	7	7	8		8	9	8	8		7
GSA20_500-800	3	3	4	3	5	5	5	5		5	4	5	4		6

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.28.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.28.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 20 was derived from the international survey Medits. Figure 5.28.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 20. No survey was conducted in 2009.

The estimated abundance and biomass indices do not reveal any significant trends since 1997 when the indices increased from a lower level. The analyses of Medits indices are considered preliminary.

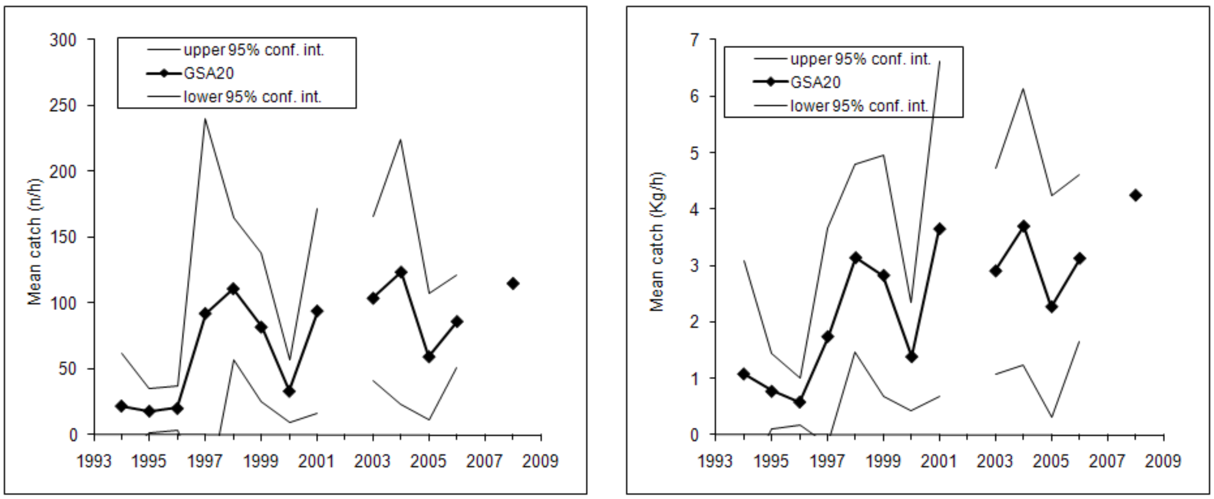


Fig. 5.28.3.1.3.1 Abundance and biomass indices of red mullet in GSA 20.

5.28.3.1.4. *Trends in abundance by length or age*

The following Fig. 5.28.3.1.4.1 and 2 display the stratified abundance indices of GSA 20 in 1994-2001 and 2003-2008. No survey was conducted in 2007 and 2009.

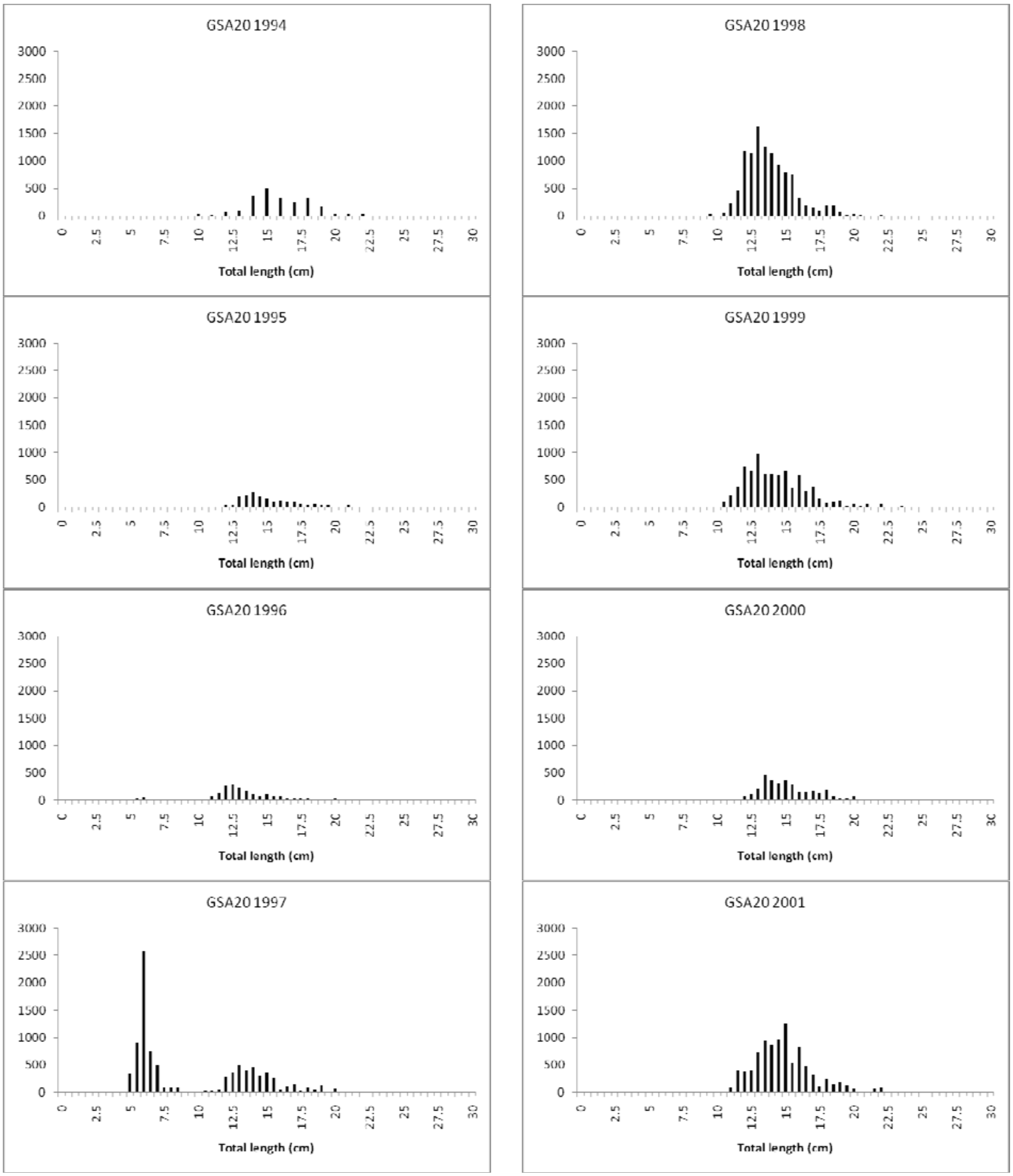


Fig. 5.28.3.1.4.1 Stratified abundance indices by size, 1994-2001.

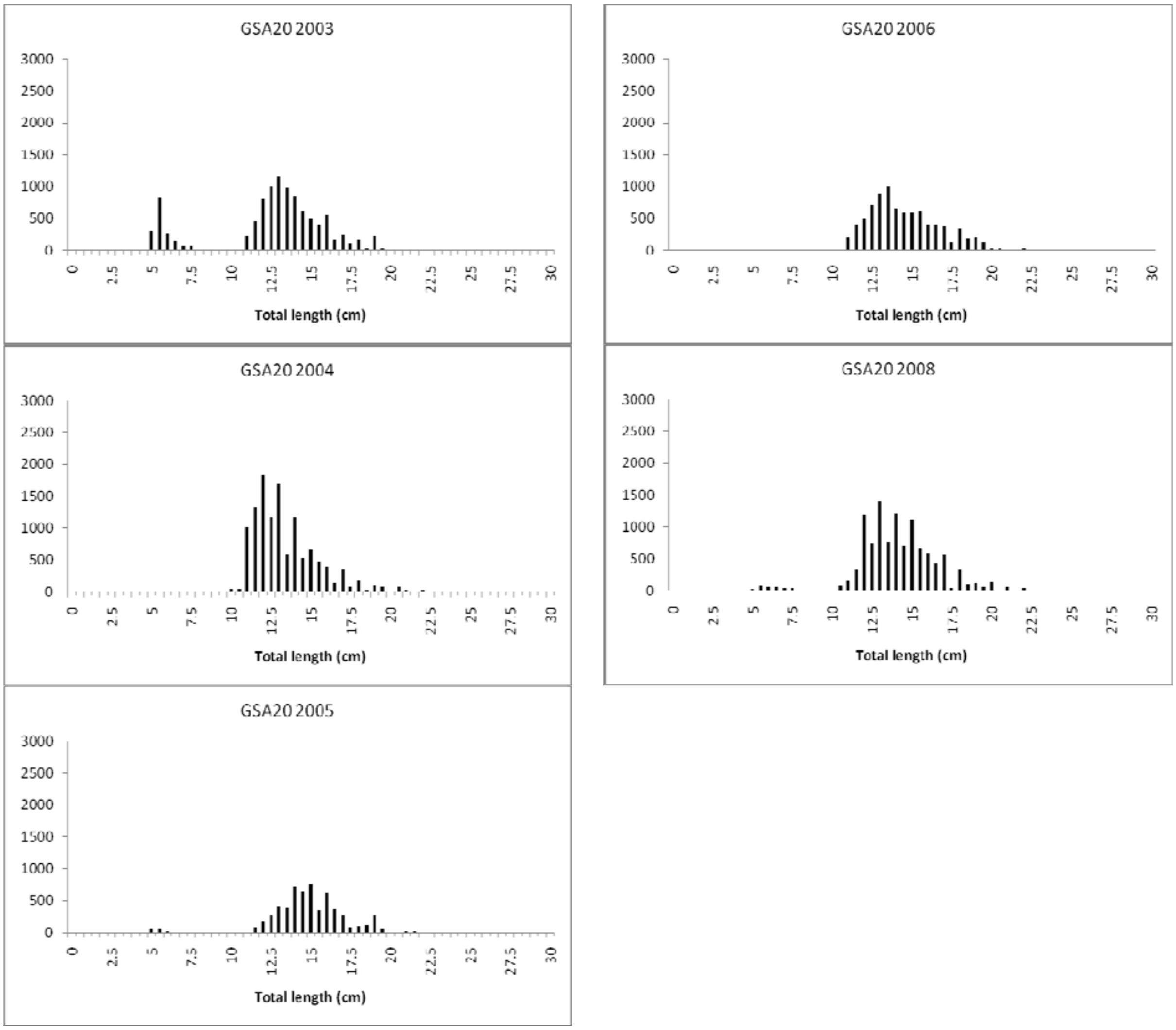


Fig. 5.28.3.1.4.2 Stratified abundance indices by size, 2003-2008.

5.28.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.28.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.28.4. Assessment of historic stock parameters

SGMED 10-02 did not undertake any analytical assessment of red mullet in GSA 20. The most recent preliminary assessment using SURBA can be found in the report of SGMED-08-04 working group (Cardinale *et al*., 2008).

5.28.5. Long term prediction

5.28.5.1. Justification

No forecast analyses were conducted.

5.28.5.2. Input parameters

No forecast analyses were conducted.

5.28.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for red mullet in GSA 20.

5.28.6. Scientific advice

5.28.6.1. Short term considerations

5.28.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock due to a lack of proposed or agreed precautionary reference points and the preliminary state of the data and analyses.

5.28.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.28.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation due to the lack of proposed or agreed managenent reference points and the preliminary state of the data and analyses.

5.29. Stock assessment of red mullet in GSAs 22 and 23 combined

5.29.1. Stock identification and biological features

5.29.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.29.1.2. Growth

No information was documented during SGMED-10-02.

5.29.1.3. Maturity

No information was documented during SGMED-10-02.

5.29.2. Fisheries

5.29.2.1. General description of fisheries

The red mullet (*Mullus barbatus*) stock in the Aegean is exploited by both the Greek and Turkish fishing fleets. The bottom trawl fishery in Greece is a mixed fishery, operating from the beginning of October until the end of May, as a 4-month fishery closure (June-September) for bottom-trawlers is enforced by national legislation. The minimum mesh size of the cod end of bottom trawls is 40 mm.

5.29.2.2. Management regulations applicable in 2009 and 2010

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone 1.5 mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1st of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2010, the net should have been replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship-owner, by a diamond meshed net of 50 mm. So far, only a few boats have actually replaced their nets.

Several additional restrictions exist for bottom trawling in specific areas. For example in Amvrakikos Gulf, Pagassitikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1st of March till the end of November.

The operation of the bottom set nets is subject to the following main restrictions:
(1) the maximum total length of the trammel net is 6000 m.
(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2,500 m.

5.29.2.3. Catches

5.29.2.3.1. Landings

Estimation of landings was based on random sampling in 127 sampling stations (ports) in GSA 22-23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and landings by species recorded. Based on these data, average landings per fishing day, by species and for each fishing gear were estimated. Based on total effort estimations, sampled data were raised to the whole fleet to estimate total landings by species, fleet segment, fishing gear and GSA. Tab. 5.29.2.3.1.1 shows the trend in reported landings taken by major gear types. The data were reported to SGMED-10-02 through the Data Collection Regulation.

Tab. 5.29.2.3.1.1 Greek landings (t) by year and major gear types, 2002-2008 as reported through DCF.

SPECIES	AREA	COUNTRY	FT_LVL4	<>	2002	2003	2004	2005	2006	2007	2008
MUT	20	GRC	GTR			2104	728	514	432		654
MUT	20	GRC	OTB			164	180	226	154		406
MUT	20	GRC	SB			87	28	37	24		39
MUT	22	GRC	FPO								4
MUT	22	GRC	GTR			2366	1127	1589	1687		1028
MUT	22	GRC	OTB			1770	2145	1681	1191		1376
MUT	22	GRC	PS				0	0			
MUT	22	GRC	SB			186	167	286	219		190

5.29.2.3.2. Discards

No discards data were reported to SGMED-10-02 through the DCF data call for Greece.

5.29.2.3.3. Fishing effort

Estimation of effort was based on interviews conducted with random sampling in 127 sampling stations (ports) in GSA 22-23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive, and the proportion of the year they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, fishing gear, and GSA. It should be noted that the estimated effort refers to the entire effort of each fleet segment. Tab. 5.29.2.3.3.1 lists the fishing effort reported to SGMED-10-02 through the DCR data call.

Tab. 5.29.2.3.3.1 Fishing effort in different units by fishing technique deployed in GSA 22-23, 2003-2008.

TYPE	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DAYS	22	GRC	GTR		2078058	1908626	1993815	1914951		1374948
DAYS	22	GRC	LLS		20905	41155	41568	51501		302098
DAYS	22	GRC	OTB		52536	53381	56580	53367		51855
DAYS	22	GRC	PS		44481	43772	48211	42874		40029
DAYS	22	GRC	SB		36266	31987	33200	30098		25138
GT*DAYS	22	GRC	GTR		8567144	8034837	7939836	7571041		5309125
GT*DAYS	22	GRC	LLS		332005	577572	603419	780138		1244484
GT*DAYS	22	GRC	OTB		4927349	4972085	5553804	5556446		5355704
GT*DAYS	22	GRC	PS		1998124	1987556	2295466	2108039		1930332
GT*DAYS	22	GRC	SB		294896	269645	276265	257271		214985
KW*DAYS	22	GRC	GTR		68845607	70633794	70746878	66780942		50244080
KW*DAYS	22	GRC	LLS		1888201	4977272	2715667	3848302		7914684
KW*DAYS	22	GRC	OTB		15792715	15874762	17730748	16424382		16013057
KW*DAYS	22	GRC	PS		9389351	9140980	9656463	8992650		8233643
KW*DAYS	22	GRC	SB		2775797	2206815	2193550	2022231		1774864

5.29.3. Scientific surveys

5.29.3.1. Medits

5.29.3.1.1. Methods

The MEDITS survey was carried out in GSAs 22-23 every summer from 1994 to 2008, except in 2002, 2007 and 2009 because of administrative problems. In GSA 22 and 23, the number of stations was 98 in 1994 and gradually increased to 146 in 1996 and onwards. Due to this change in the survey design, caution is needed when investigating the trends of relevant indicators in the MEDITS time series unless the data are properly standardised. More details on methodology and trends on selected indicators may be found in MEDITS (2007).

Based on the DCR data call, abundance and biomass indices were calculated. In GSAs 22 and 23 the following number of hauls were reported per depth stratum (s. Tab. 5.29.3.1.1.1).

Tab. 5.29.3.1.1.1. Number of hauls per year and depth stratum in GSAs 22 and 23, 1994-2008. No survey was conducted in 2009

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GSA22+23_010-050	10	10	11	10	13	12	13	13		13	13	14	14		13
GSA22+23_050-100	19	21	22	28	24	26	21	25		25	23	24	24		27
GSA22+23_100-200	19	26	38	36	36	33	38	35		36	43	41	41		40
GSA22+23_200-500	32	35	45	50	51	54	50	48		51	53	52	52		52
GSA22+23_500-800	18	13	19	22	22	21	20	17		17	17	17	17		17

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution or a quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al.* (2004)).

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.29.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.29.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 22 and 23 was derived from the international survey MEDITS. Fig. 5.29.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 22 and 23. The estimates did not show any trend in both abundance and biomass.

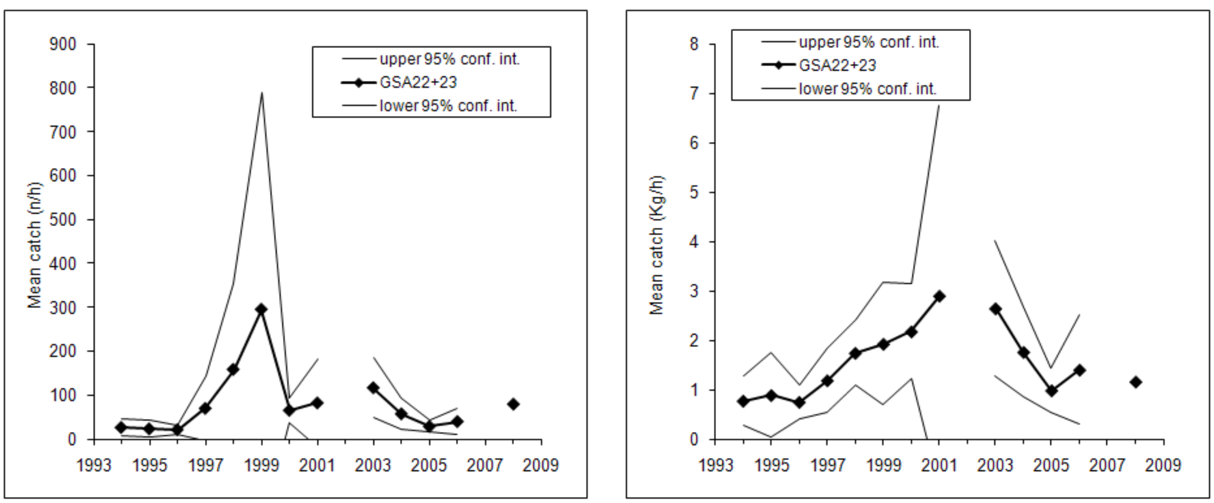


Fig. 5.29.3.1.3.1 Abundance and biomass indices of red mullet in GSAs 22 and 23. No survey was conducted in 2009.

5.29.3.1.4. Trends in abundance by length or age

The following Fig. 5.29.3.1.4.1 and 2 display the stratified abundance indices of GSAs 22 and 23 in 1994-2001 and 2003-2008.

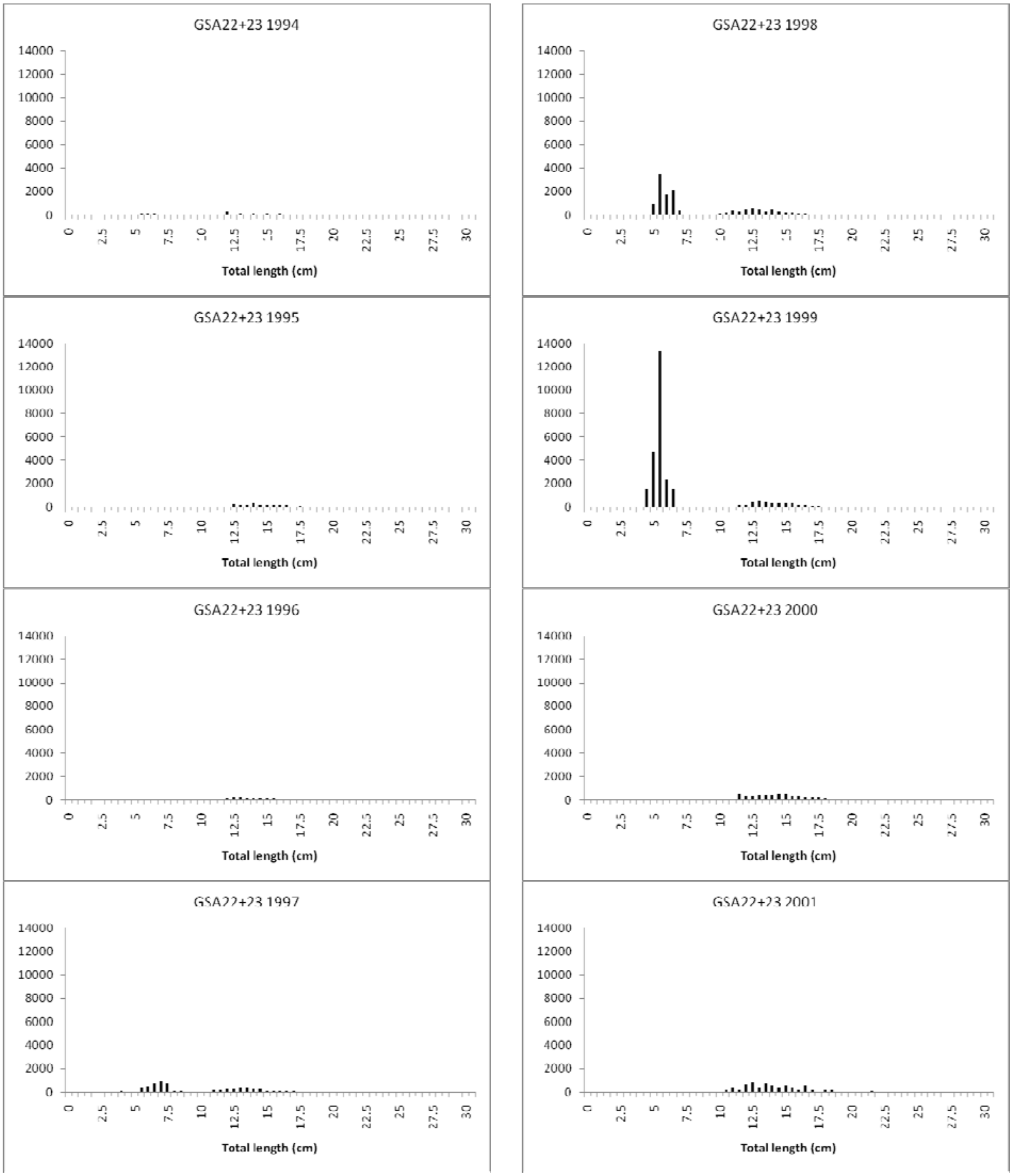


Fig. 5.29.3.1.4.1 Stratified abundance indices by size, 1994-2001.

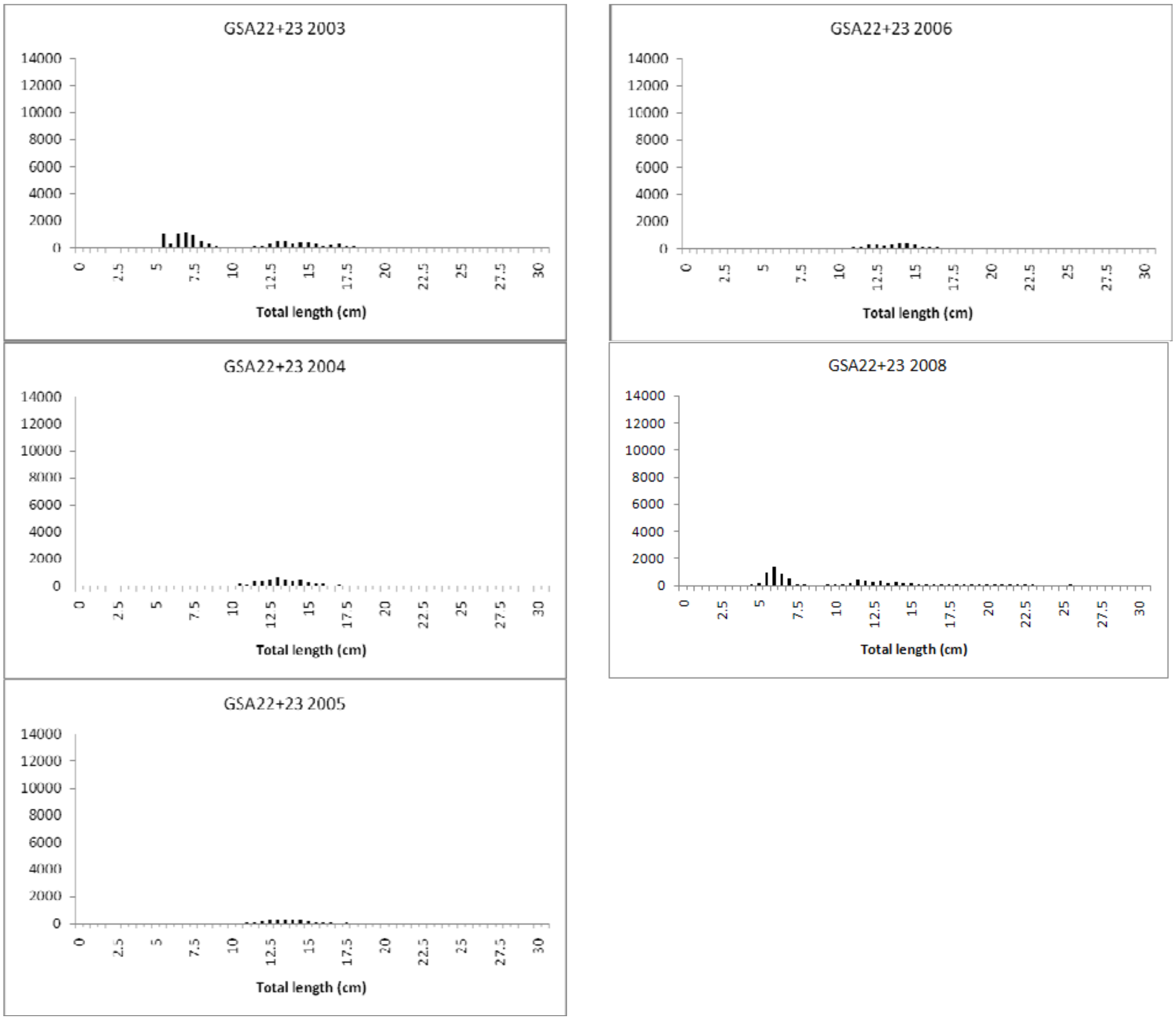


Fig. 5.29.3.1.4.2 Stratified abundance indices by size, 2003-2008. No survey was conducted in 2009.

5.29.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.29.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.29.4. Assessment of historic stock parameters

A new assessment is presented based on surplus production. Age-based assessments could not be carried out due to lack of sufficient catch-at-age information. Attempts to analyze MEDITS survey data through the SURBA software failed as no proper model fitting was achieved.

5.29.4.1. Method 1: Surplus production model

5.29.4.1.1. Justification

The assessment estimates for the red mullet (*Mullus barbatus*) stock were based on the logistic surplus production model (Schaefer 1954) using a non-equilibrium approach which utilizes a time series of CPUE and fisheries landings data (Tserpes, 2008).

The model is described below:

For a given r value the following approach has been followed:

1. Estimation of harvest rate for the beginning of the period

$$hr = \frac{F}{Z} \times (1 - e^{-Z})$$

2. Estimation of initial biomass fraction (i.e. B/k)

$$B_{fr} = 1 - \frac{hr}{r}$$

3. Estimation of a starting k value

$$k_{in} = \frac{C_{av} \times 4}{r}$$

(assumes that average catch is around to MSY).

4. Estimation of initial biomass

$$B_0 = B_{fr} \times k_{in}$$

5. Estimation of a starting q value

$$q_{in} = \frac{U_{av}}{B_0}$$

(U_{av}=mean abundance index)

6. Final estimates of model parameters *(k, q)* were obtained using a least squares criterion of fit assuming log-normally distributed residual errors between observed and expected abundance indices.

The equations used were:

$$B_t = B_{t+1} + rB_{t-1}(1 - \frac{B_{t-1}}{k}) - C_{t-1}$$

$$U_t = q \times B_t$$

$$\varepsilon_t = (\log U_t - \log \hat{U}_t)^2$$

$$U_t = (B_{t-1} + rB_{t-1}(1 - \frac{B_{t-1}}{k}) - C_{t-1}) \times q$$

The above steps have been repeated for a series of consecutive r values (range 0.30-0.99, interval 0.01). As the best model, was considered that providing the lowest error and its parameters were used to calculate population biomass time series as well as equilibrium MSY, B_{msy} and F_{msy} rates. Confidence intervals were estimated through bootstrapping. Model estimates were made by means of computer code developed in R-language.

5.29.4.1.2. Input parameters

The following data were used as input for the model:

Total Greek Aegean landings by year for the period 1990-2006 were extracted from the National Statistical Service of Greece (NSSG) database and reconstructed to include small scale coastal fisheries catches based on the approach by Tsikliras et al. (2007) (Table 5.29.4.1.2.1). Landings of the eastern Aegean (Turkey) were extracted from the GFCM database.

Tab. 5.29.4.1.2.1 Red mullet Aegean landings (in kg) for the period 1990-2006.

Year	Landings (kg)
1990	4199719
1991	5776047
1992	4780411
1993	4769138
1994	5516913
1995	5458223
1996	4979264
1997	4810225
1998	4388776
1999	4535638
2000	4254464
2001	4061994
2002	3810284
2003	3361794
2004	3890664
2005	4228530
2006	4516480

A yearly index of MEDITS CPUE series for the period 1996-2006 (excluding 2002 for which no data were available) based on data from the MEDITS project for GSA 22 and 23 (www.ifremer.fr/Medits_indices) (Table 5.29.4.1.2.2). The abundances of 0 group age class were not included in the index because they show a great interannual variability due to fluctuations in time of recruitment.

Table 5.29.4.1.2.2 Red mullet in GSA 22. MEDITS CPUE index for 1996-2006.

Area	Year	CPUE index
22	1996	16.02
22	1997	21.41
22	1998	20.93
22	1999	15.01
22	2000	16.09
22	2001	17.04
22	2002	-
22	2003	12.23
22	2004	17.16
22	2005	16.41
22	2006	19.95

Exploitation rate at the beginning of the studied period based on the mortality estimates of the latest VPA assessment. Values of F and M for the beginning of the period were fixed to 0.80 and 0.48 respectively (Vassilopoulou and Papaconstantinou, 1991).

5.29.4.1.3. Results

The best fit was provided for r = 0.79 (0.62-0.96) and k=26744 t (20977-32510). Based on the above estimates, equilibrium MSY was 5296 t (Figure 5.29.4.1.3.1). The corresponding rates for fishing mortality and biomass were: F_{MSY} =r/2=0.39 and B_{MSY} =k/2=13372 t. Annual catches in the latest years are below MSY and stock biomass levels are increasing since 1998 and in 2006 exceed B_{MSY} (Figure 5.29.4.1.3.2). However, the estimated confidence intervals are also increasing. CPUE are fluctuating with no trend (Figure 5.29.4.1.3.3).

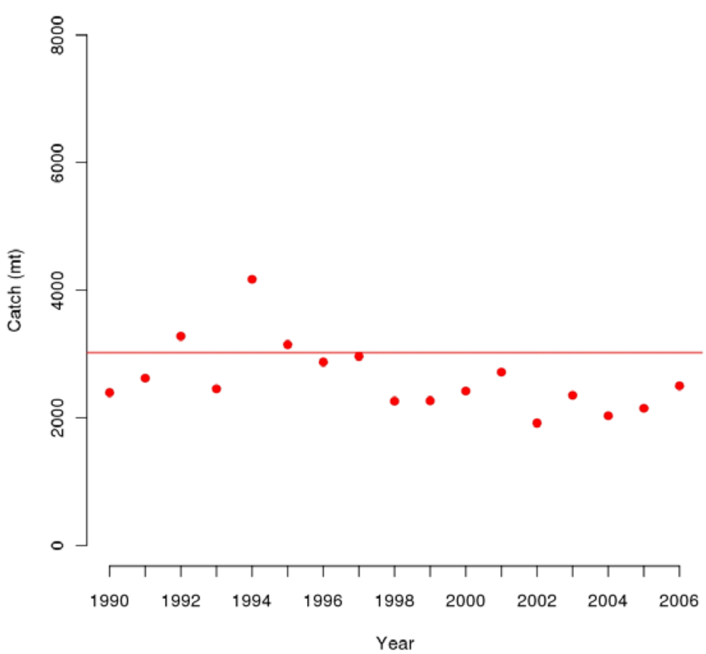


Figure 5.29.4.1.3.1. Red mullet catch by year (red points) and MSY levels (red horizontal line).

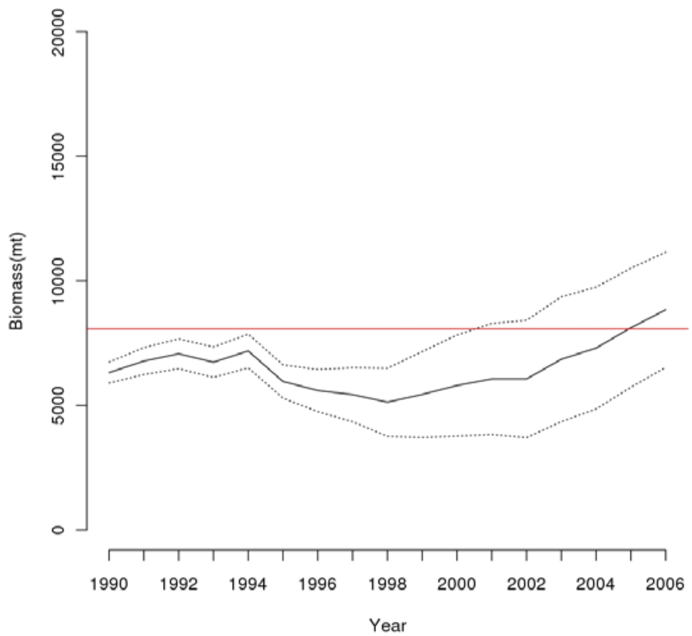


Figure 5.29.4.1.3.2. Red mullet biomass (black solid line) by year and BMSY levels (red horizontal line).

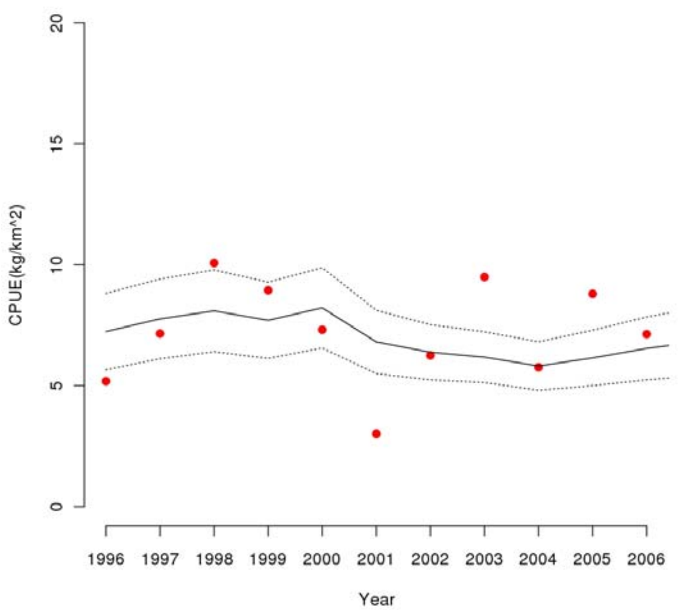


Figure 5.29.4.1.3.3. Red mullet CPUE by year (red points) and model fitted line.

5.29.5. Long term prediction

5.29.5.1. Justification

A Y/R analysis was conducted using the Yield software.

5.29.5.2. Input parameters

Growth parameters

L_8	28.5
k	0.3
to	-0.5

Weight-length relationship

a (W-L)	0.03
b (W-L)	3

Natural mortality	0.45
Age at maturity	1
Age at first capture	0.7

5.29.5.3. Results

Table 5.29.5.3.1 lists the reference points estimated from the yield per recruit analysis.

Table 5.29.5.3.1 Fisheries management reference values derived from yield per recruit analysis.

	Y/R
F_{max}	0.48
$F_{0.1}$	0.28

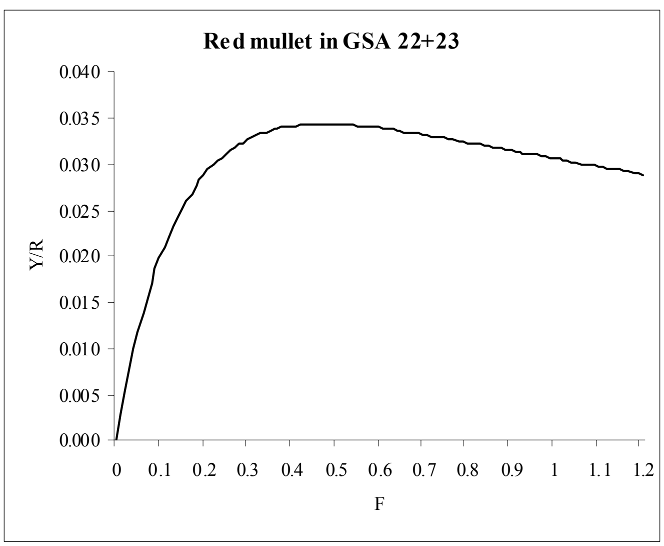


Figure 5.29.5.3.1. Yield (kg) per recruit for red mullet in GSA 22-23.

5.29.6. Data quality

The lack of catch-at-age data did not allow the use of an age-based assessment that would provide a more detailed and robust information about the stock status. The quality of existing data did not seem to have any negative effect on the applied models. However, SGMED notes that due to lack of recent data, the assessment relies on data up to 2006 only and a more recent assessment of stock is lacking. Also, SGMED considers that the interruption of the survey time series and the lack of catch and weight at age data from the landings will preclude the assessment and management of red mullet in GSA 22-23 in the next years.

5.29.7. Scientific advice

5.29.7.1. Short term considerations

SGMED-10-02 considers all analyses presented to assess the status of red mullet in GSAs 22 and 23 as preliminary and not suitable to provide sound scientific advice.

5.29.7.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice regarding the state of the spawning stock.

5.29.7.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice regarding the state of the recruitment given the preliminary state of the data and analyses.

5.29.7.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice regarding the state of the exploitation given the preliminary state of the data and analyses.

5.30. Stock assessment of red mullet in GSA 25

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.30.1. Stock identification and biological features

5.30.1.1. Stock Identification

Red mullet is a common demersal fish in the Mediterranean Sea, found in depths ranging from 10-200 m, and mostly distributed in depths less than 100 m. It inhabits sandy and muddy bottoms. The species in GSA 25 is considered as a single stock, though this has not been evidenced by studies on population structure.

5.30.1.2. Growth

The von Bertalanffy growth parameters of red mullet in GSA 25 were estimated using otolith readings; the estimates for sex combined data, for the years 2006-2008, are the following:
L_{inf} = 26.61, K=0.183 and t_0=-2.488.

Parameters of the length-weight relationship, related to sex combined data for the years 2006-2008, are: a=0.00797, b = 3.12 (for length expressed in cm).

The data used for the growth parameters were collected under the Cyprus National Data Collection Programme, within the Data Collection Regulation framework, and were provided through the 2009 Spring Official EC Data Call.

5.30.1.3. Maturity

The maturity ogive of the stock (sex combined), as provided through the 2009 Spring Official EC Data Call, is presented in Table 5.30.1.3.1. Data used were collected under the Cyprus National Programme during 2006-2008.

Tab. 5.30.1.3.1: Maturity ogive of *M. barbatus*.

TL (cm)	Proportion of mature
7	0.00
8	0.33
9	0.60
10	0.87
11	0.88
12	0.88
13	0.94
14	0.95
15	0.98
16	0.99
17	1.00

5.30.2. Fisheries

5.30.2.1. General description of fisheries

Red mullet in GSA 25 is exploited with other demersal species by the bottom otter trawlers and the artisanal fleet using set nets (basically trammel nets). The main species caught with *M. barbatus* are: *Spicara* spp. (mostly *S. smaris*), *Boops boops*, *M. surmuletus*, *Pagellus erythrinus* and cephalopods (*Octopus vulgaris*, *Loligo vulgaris* and *Sepia officinalis*). The artisanal (inshore) fishery catches also relatively large quantities of *Diplodus* spp, *Sparisoma cretense* and *Siganus* spp. The average percentage of *M. barbatus* in the overall landings of the bottom trawl and artisanal fishery, for the period 2005-2008, was 7% and 2% respectively.

The average composition of the landings of the artisanal and the bottom trawl fishery during the period 2002-2006 is provided in Figure 5.30.2.1.1.

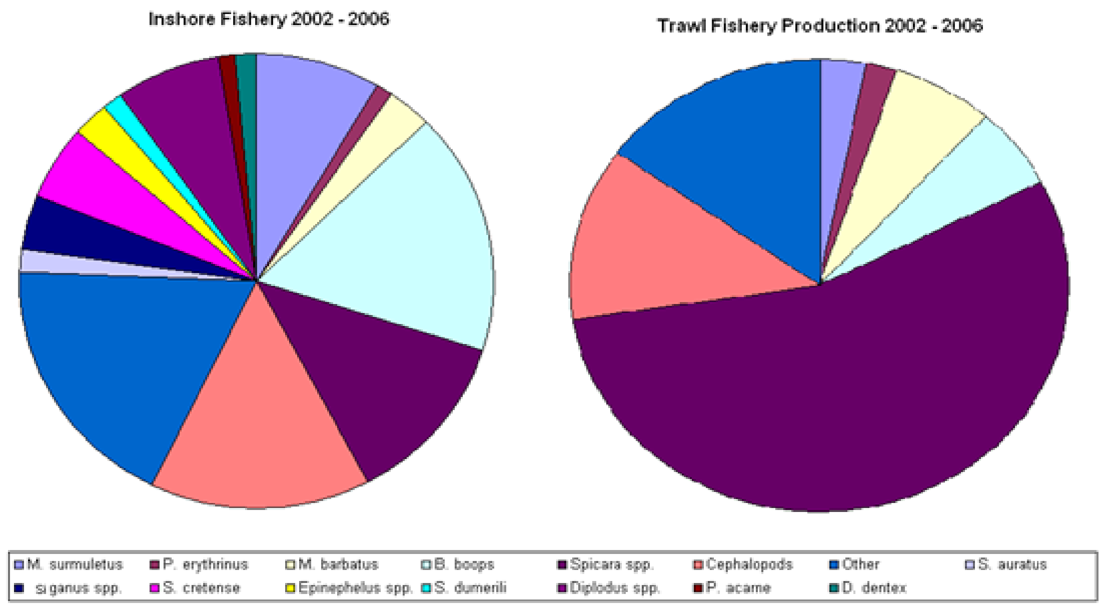


Fig. 5.30.2.1.1. Composition of landings of the artisanal and trawl fishery in Cyprus for the period 2002-2006.

Discards from the bottom otter trawl were evaluated for the first time in 2006, through a pilot study carried out as part of the 2006 Cyprus National Fisheries Data Collection Programme. The study suggested that discard quantities of *M. barbatus* are less than 1% in terms of biomass and 2% in terms of numbers. Discards from the artisanal fishery are considered negligible.

5.30.2.2. Management regulations applicable in 2009 and 2010

The National and Community legislation provide for a number of management measures for the regulation of the Cyprus fisheries, including:

- Restrictive access to the fisheries (limited number of licenses for each fleet segment).
- Effort control: Restrictions on the use of fishing gears (quantities, soaking time, depth and distance off shore) and regulation of fishing capacity (scrapping, assignment for other uses than fishing, engine restrictions, ceiling of the fleet vessel register).
- Market restriction measures: minimum landing sizes for several species. For red mullet the minimum landing size applied is 11 cm (as set in Regulation (EC) 1967/2006).
- Technical conservation measures: minimum mesh sizes.
- Seasonal and area closures.

For the bottom otter trawl fishery in terrirorial waters (GSA 25) the following management measures were applicable in the years 2007-2008:

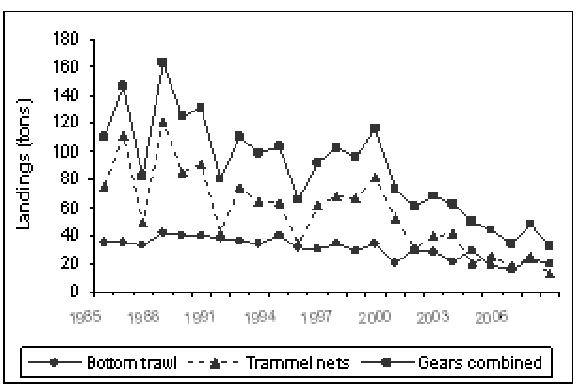
– Maximum number of licenses restricted to 4.
– Closed trawling period from the beginning of June until the 7th of November (in force since the mid ’80s).
– Minimum mesh size of the trawl net at 40mm (diamond shape). It is noted that from November 2009 the trawl net will be replaced by a square meshed net of 40 mm at the cod-end or by a diamond meshed net of 50 mm, in accordance with the provisions of the new Mediterranean Regulation (EC) No 1967/2006.
– Prohibition of bottom trawling at depths less than 50 meters and at distances less than 0.7 nautical miles off the coast. From November 2008 there is a prohibition of bottom trawling at distances between 0.7 and 1.5 nautical miles in certain areas within the terrirtorial waters, with the intention to fully implement this measure in all territorial waters.

For the artisanal fishery the following management measures were applicable in the years 2007-2008:
– Assignment of licensed fishermen in 3 categories, based on their fishing activity and certain criteria.
– Restriction of the maximum number of licenses
– Implementation of the provisions of the Mediterranean Regulation on restrictions on the use of fishing gears. Implementation of additional restrictions on fishing effort (use of fishing gears and number of fishing days) depending on the fishing license category.

5.30.2.3. Catches

5.30.2.3.1. Landings

Figure 5.30.2.3.1.1. provides the official landings of *M. barbatus* in GSA 25 by fishing gear, for the years 1985-2008. The figure presents a declining trend in the landings from both gears, mostly from the trammel nets. For the same period, the overall LPUE by fishing fleet (all gears combined for the artisanal fishery) is provided in same Figure. LPUE of both fleets show a declining trend until 2006; since then, LPUE for the artisanal fleet seems to be stable, while for the bottom trawl fishery LPUE in 2007 reached the highest value of the time period. It is noted that since 2006 the number of licensed bottom trawlers operating in GSA 25 has been reduced by 50% (from 8 to 4).



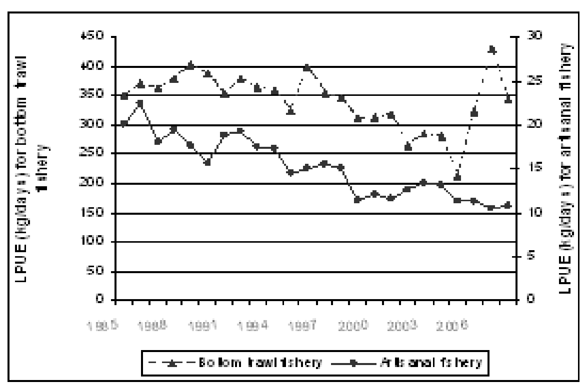
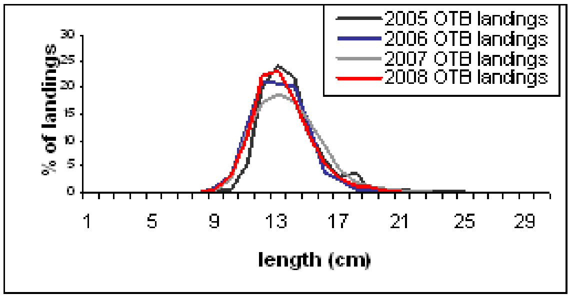


Fig. 5.30.2.3.1.1: Landings and LPUE of *M. barbatus* in GSA 25 by fishing gear for the period 1985-2008.

Data on landings and fishing effort are collected by the Department of Fisheries and Marine Research by the following sources:
- Logbooks (for vessels larger than 12 m)
- Landing declarations/inshore reports (from a 15% sample of licensed vessels less than 12m)
- Sampling of vessels at landing sites (for vessels less than 12m)

Landings data provided through the 2009 Spring Official EC Data Call refer to the years 2005-2008. The length distribution of the landings for this period for each fishing gear, as officially submitted, is provided in Figure 5.30.2.3.1.2.



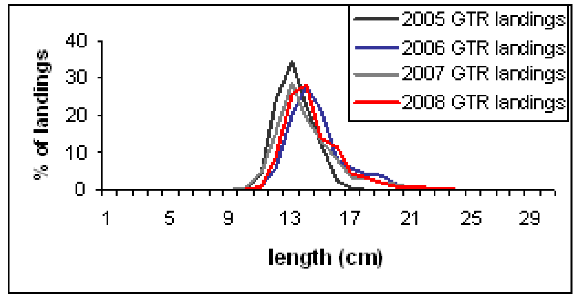


Fig. 5.30.2.3.1.2: Landings length distribution of *M. barbatus* in GSA 25 per fishing gear for the years 2005-2008.

Table 5.30.2.3.1.1 Landings (t) as reported throught the official DCF data call in 2010. No landings in 2009 were reported by Cyprus.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUT	25	CYP	GTR	DEMSP					25	18	25	13	
MUT	25	CYP	OTB	DEMSP					18	16	23	20	
Sum									43	34	48	33	

5.30.2.3.2. Discards

The estimation of discards of the species involves on-board sampling of bottom otter trawlers; data are collected under the Cyprus National Data Collection Programme since 2006. Discards from the artisanal fishery is considered negligible.

The discard estimates of *M. barbatus* in terms of weight for 2006 and 2008 were less than 200 kg (as provided through the 2009 Spring Official EC Data Call), accounting for about 1% of the total catch of the species. Under the official call, data were also sent on discards length distribution for the year 2008 (provided in figure 5.30.2.3.2.1).

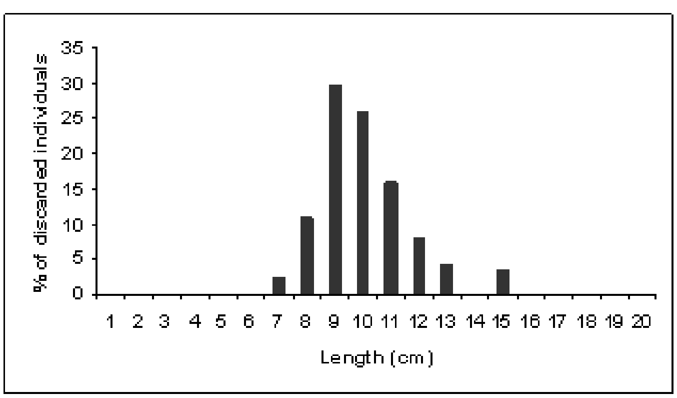


Fig. 5.30.2.3.2.1: Discards length distribution of *M. barbatus* in GSA 25 for the year 2008.

5.30.2.3.3. Fishing effort

Fishing effort data in GSA 25 were provided according to the 2010 Data Call. Table 5.30.2.3.3.1 lists the reported effort by fishing technique deployed in GSA 25.

Tab. 5.30.2.3.3.1 Effort (kW*days) by métier in GSA 25, 2005-2008. No data for 2009 were provided.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
25	CYP	GTR	DEMSP		VL0012			3271955	3496397	3860088	3736472	
25	CYP	GTR	DEMSP		VL1224			33696	31803	36746	35714	
25	CYP	LLS	DEMSP		VL1224			273054	307358	286591	278925	
25	CYP	OTB	DEMSP		VL1224			327616	231816	240182	246889	

5.30.3. Scientific surveys

5.30.3.1. Medits

5.30.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 25 the following numbers of hauls were reported per depth stratum (s. Tab. 5.30.3.1.1.1).

Tab. 5.30.3.1.1.1. Number of hauls per year and depth stratum in GSA 25, 2005-2009.

STRATUM	2005	2006	2007	2008	2009
GSA25_010-050	5	5	5	5	5
GSA25_050-100	8	8	8	9	9
GSA25_100-200	5	5	5	5	5
GSA25_200-500	3	3	3	3	3
GSA25_500-800	4	4	4	5	5

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum

Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.30.3.1.2. Geographical distribution patterns

Figure 5.30.3.1.2.1. provides the distribution of sampling hauls of the Medits survey in GSA 25. No analyses on geographical distribution patterns were conducted during SGMED-10-02.

Fig. 5.30.3.1.2.1. Distribution of sampling hauls of the Medits survey in GSA 25.

5.30.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 25 was derived from the international survey Medits. SGMED-10-02 notes that the MEDITS survey covers only the southern and north-western slopes off Cyprus.

Figure 5.30.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 25. The estimated abundance and biomass indices do not reveal any significant trends since 2005 and are subject to high variability (uncertainty). This trend seems to be in agreement with the trend in the landings during the same period (see Fig. 5.30.2.3.1.1).

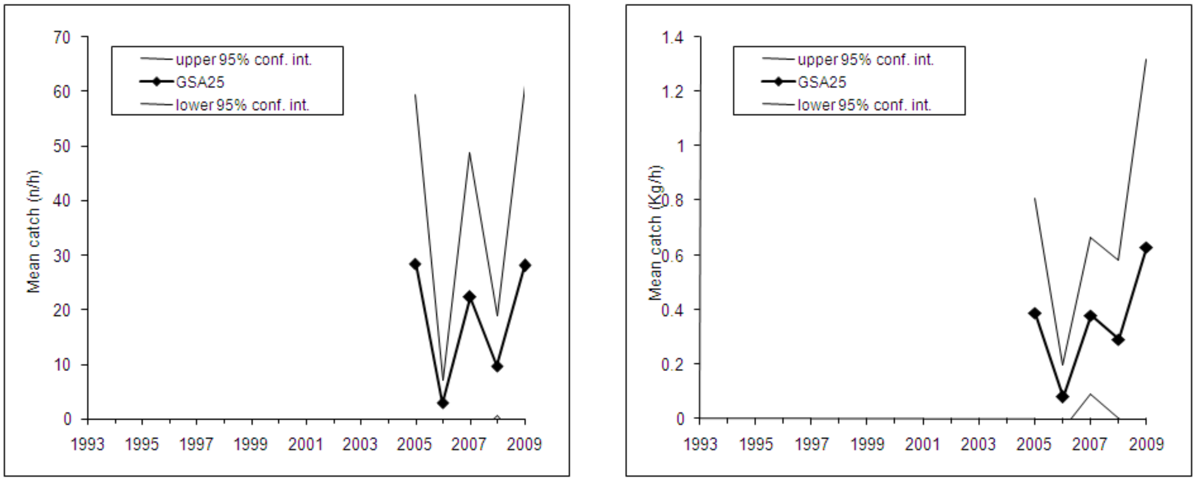


Fig. 5.30.3.1.3.1 Abundance and biomass indices of red mullet in GSA 25.

5.30.3.1.4. Trends in abundance by length or age

The following Fig. 5.30.3.1.4.1 displays the stratified abundance indices of GSA 25 in 2005-2009. These size compositions are considered preliminary.

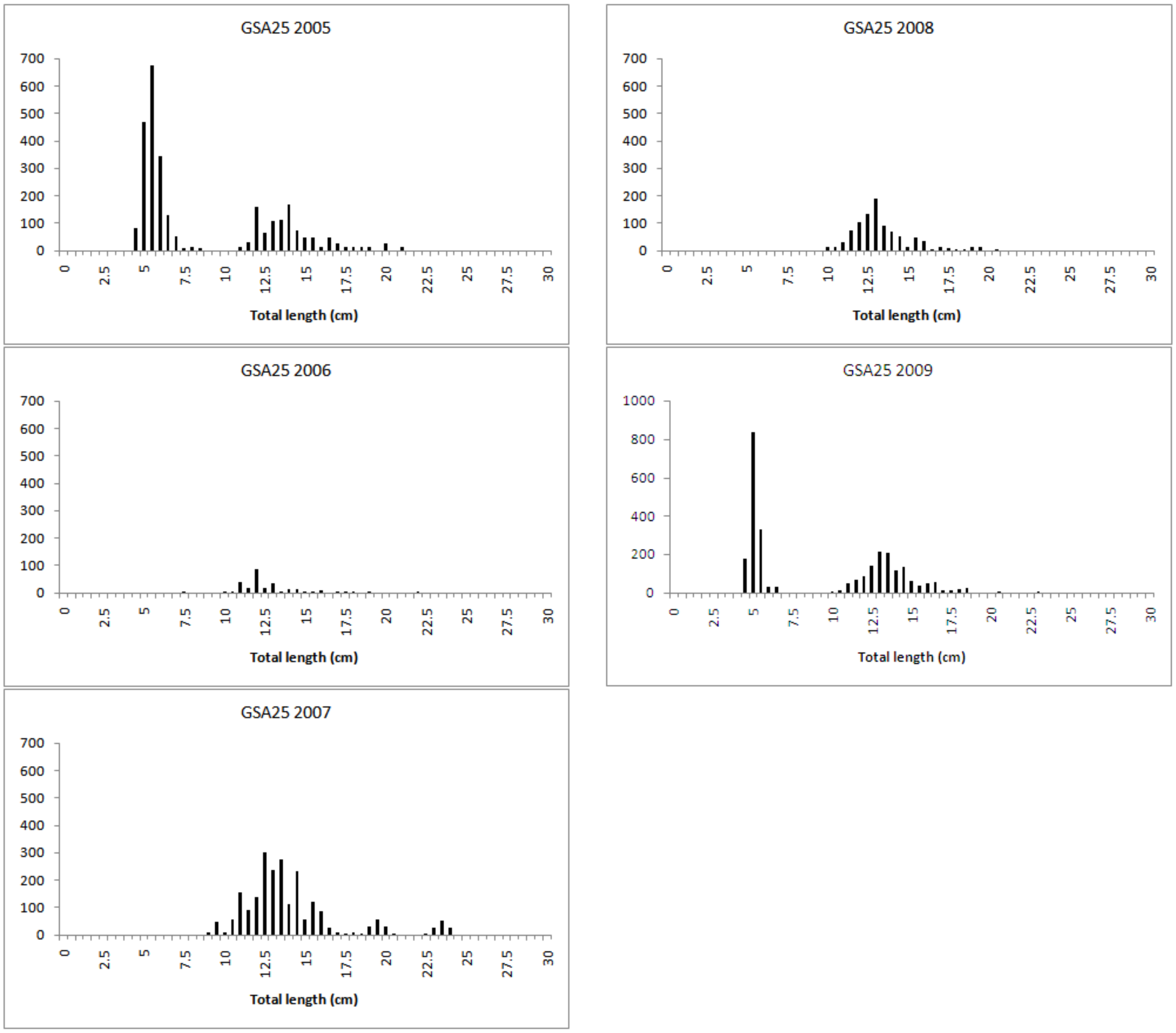


Fig. 5.30.3.1.4.1 Stratified abundance indices by size, 2005-2009.

5.30.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.30.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.30.4. Assessment of historic stock parameters

5.30.4.1. Method 1: VIT

SGMED-10-02 did not update the following analyses as no data for 2009 were available.

5.30.4.1.1. Justification

Due to the short time data series provided under the DCR Data Call (2005-2008), and the almost equal exploitation of the stock by two fishing gears, the VIT software (Lleonart and Salat, 1992) was considered as the most appropriate software for assessing the stock in GSA 25.

The assessment was performed by means of VPA analysis (running the classic catch equation - Gulland 1965), using a mean pseudo-cohort from catch-at-age data for the period 2005-2008.

5.30.4.1.2. Input parameters

The biological parameters used were the ones collected within the framework of the Cyprus National Data Collection Programme and submitted under the 2009 Spring Official EC Data Call:

- VBGF growth parameters: L_{inf} = 26.61, K=0.183 and t_0= -2.488.
- Length-weight relationship: a = 0.00797, b = 3.12 (for length expressed in cm)
- Maturity ogive by age class (transformed from submitted maturity at length class, as shown in table 5.30.4.1.2.1)

Tab. 5.30.4.1.2.1 Maturity at Age for *M. barbatus* in GSA 25 for the period 2006-2008.

Age	0	1	2	3	4	5	6	7
Prop. Matures	0.465	0.9	0.94	1	1	1	1	1

An M vector was used, as estimated by PRODBIOM spreadsheet (Abella *et al*., 1997) (Table 5.30.4.1.2.2.).

Tab. 5.30.4.1.2.2 M vector used for the assessment of *M. barbatus* in GSA 25 (estimated by PRODBIOM).

PERIOD	Age	0	1	2	3	4	5	6	7
2005-2008	M	0.26	0.12	0.1	0.09	0.08	0.08	0.08	0.08

During SGMED 09-01 a range of L_{inf} between 27 to 31 cm TL was recommended to be adopted for the estimation of M of the species; since the value of L_{inf} is very close to this range, it was considered realistic. Because of the highly negative value of the parameter t_0, the following two sets of VBGF parameters were also used for estimating the M vector, for comparing the resulting values:

- L_{inf} = 34.5, K=0.34 and t_0= -0.143, proposed by SGMED 08-04 as “Fast” growth parameters
- L_{inf} = 26.01, K=0.41 and t_0= -0.4, proposed by SGMED 08-04 as “Slow” growth parameters.

Figure 5.30.4.1.2.1. provides the estimated M vectors that resulted from the Cyprus and the other two VBGF parameters. As indicated by the figure, the estimated M from the Cyprus parameters is lower than the ones estimated using the other two sets. The M values used in the final assessment are shown in Table 5.30.4.1.2.2.

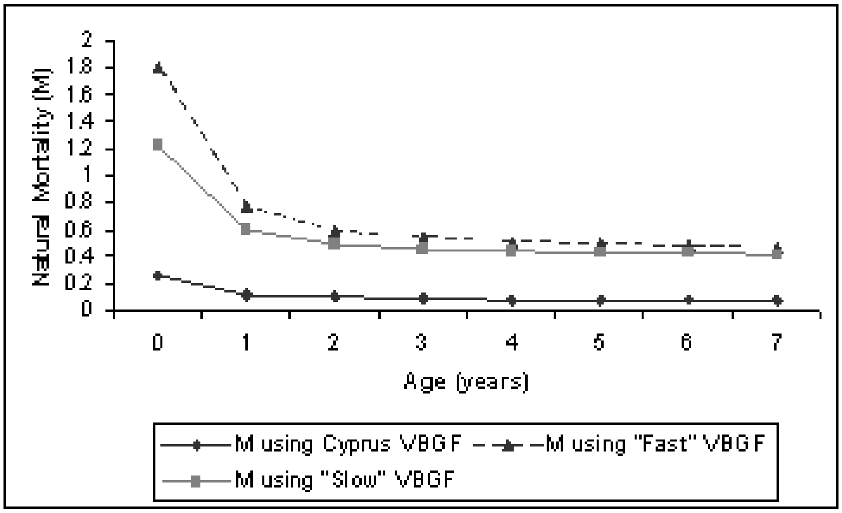


Fig. 5.30.4.1.2.1 M vectors of *M. barbatus* in GSA 25 as estimated by PRODBIOM, using different growth parameters.

Terminal fishing mortality (F_{term}) was set to 0.3. For the estimation of this parameter the length frequency data from the Medits survey (2005-2008) were used for plotting length-converted catch curves of the oldest ages, using the LFDA software (Kirkwood *et al*., 2001).

Catch-at-age data derived from landings for each fishing gear exploiting the stock (bottom otter trawl-OTB and trammel net-GTR), and discards data from bottom otter trawl. The input catch-at-age data are shown in Table 5.30.4.1.2.3.

The mean catch and the relevant percentage by fishing gear was used in terms of weight (g) (Table 5.30.4.1.2.4). The mean catch per gear was calculated using the landings and discards data, submitted under the 2009 Spring Official EC Data Call. Discards data were available only for bottom otter trawl for the years 2006 and 2008; as the discard values for these two years were similar, their average value was used for the years 2005 and 2007. Figure 5.30.4.1.2.2 provides the annual catches (in tons) by fishing gear for the period 2005-2008.

Tab. 5.30.4.1.2.3 Average age structure of *M. barbatus* catches for the period 2005-2008.

Age class	OTB Catch (%)	GTR Catch (%)
0	3.06	0.17
1	44.91	39.33
2	39.84	45.79
3	7.49	8.49
4	3.09	3.97
5	0.86	1.72
6	0.45	0.35
7	0.30	0.18

Tab. 5.30.4.1.2.4 Mean catch of *M. barbatus* for the years 2005-2008.

	Catch (tons)
Bottom Otter Trawl (OTB)	19.41 (49 %)
Trammel net (GTR)	20.21 (51 %)
Total	39.63

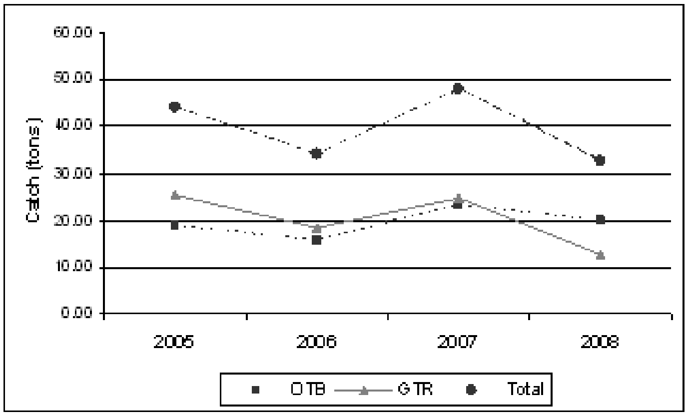


Fig. 5.30.4.1.2.2. Annual catches (t) by fishing gear for the period 2005-2008.

5.30.4.1.3. Results

Table 5.30.4.1.3.1 shows the summary results from the pseudocohort analysis on catch-at-age data, using the VBGF parameters provided by Cyprus under the Official Call. As indicated by the table the two gears show a similar exploitation patter and contribute almost equally to the landings (for the period 2005-2008). Mean age and mean length in the catch are higher (2.2 yr and 15.1 cm) than in the current stock (1.3 yr and 13 cm); figure 5.30.4.1.3.1 also shows that age class 2 is the most exploited age in the population. The estimated value of F_{mean} was 0.566, while $F_{bar\ (1\text{-}3)}$ was estimated at the value of 0.84. The mean biomass at sea was estimated at 71.72 tonnes, which is about double the mean catch for the relevant period.

Tab. 5.30.4.1.3.1 Summary results from pseudocohort analysis for *M. barbatus* in GSA 25, using the official Cyprus VBGF parameters.

	Total	Bottom trawl (OTB)	Trammel net (GTR)
Catch mean age (year)	2.185	2.109	2.262
Catch mean length (TL cm)	15.128	14.969	15.291
Mean F	0.566	0.268	0.297
Global F	0.37	0.187	0.183
F_{bar} (1-3)	0.84	0.41	0.43
Mean Catch (tons)	39.63	19.42	20.21
Catch/D%	79.04	38.73	40.31
Catch/B%	55.26	27.08	28.18
Current Stock Mean Age	1.295		
Current Stock Critical Age	1		
Virgin Stock Critical Age	0		
Current Stock Mean Length	13.037		
Current Stock Critical Length	12.555		
Virgin Stock Critical Length	9.732		
Number of recruits, R ($x10^3$)	1482.146		
Mean Biomass, B_{mean} (tons)	71.72		
Spawning Stock Biomass, SSB (tons)	58.16		
Biomass Balance, D (tons)	50.14		
Natural death/D (%)	20.96		
B_{max}/B_{mean}	33.63		
Turnover, D/B_{mean}	69.92		

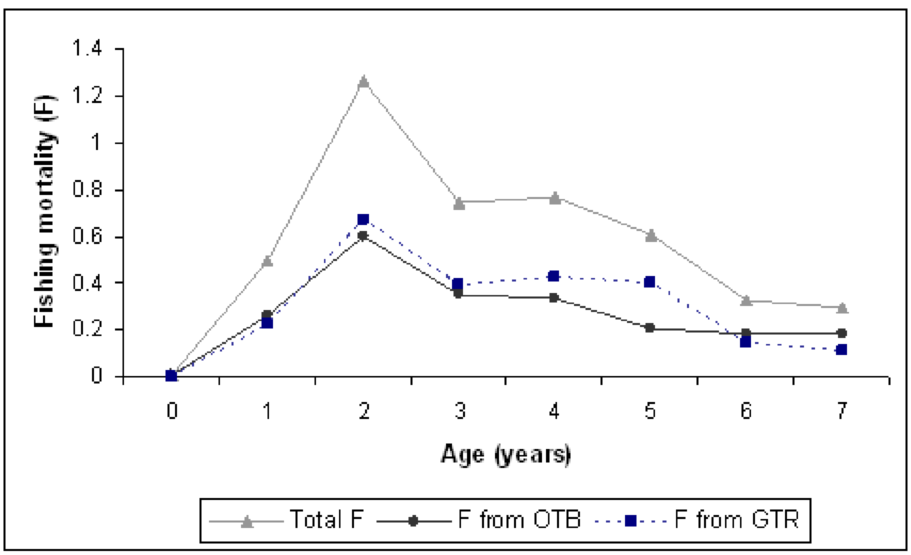


Fig. 5.30.4.1.3.1 Fishing mortality over age for *M. barbatus* in GSA 25 from pseudocohort analysis.

5.30.5. Long term prediction

5.30.5.1. Justification

Y/R analysis was conducted assuming equilibrium conditions, using VIT software.

5.30.5.2. Input parameters

For the analysis the results of VIT (pseudocohort) were used as inputs.

5.30.5.3. Results

Table 5.30.5.3.1 and Figure 5.30.5.3.1 present the results from Y/R analysis.

Tab. 5.30.5.3.1 Y/R results on *M. barbatus* in GSA 25 from VIT software.

Factor φ	B/R	SSB/R	Y/R	Y/R Bottom trawl	Y/R Trammel net
F current (1)	48.388	39.237	26.74	13.102	13.637
$F_{0.1}$ (0.38)	115.7	105.687	27.017	12.811	14.205
F_{max} (0.6)	78.922	69.255	28.4	13.596	14.803
Virgin Biomass (tons)	445.1930957				

Accepting that $F_{current}$ is equal to F_{mean} (=0.566, as estimated by the pseudocohort analysis) then the values of $F_{0.1}$ and F_{max} equal with 0.22 and 0.34 respectively. Furthermore, the results suggest that the current stock biomass (= 71.72 tons, as estimated by the pseudocohort analysis) is 16 % of the virgin stock biomass.

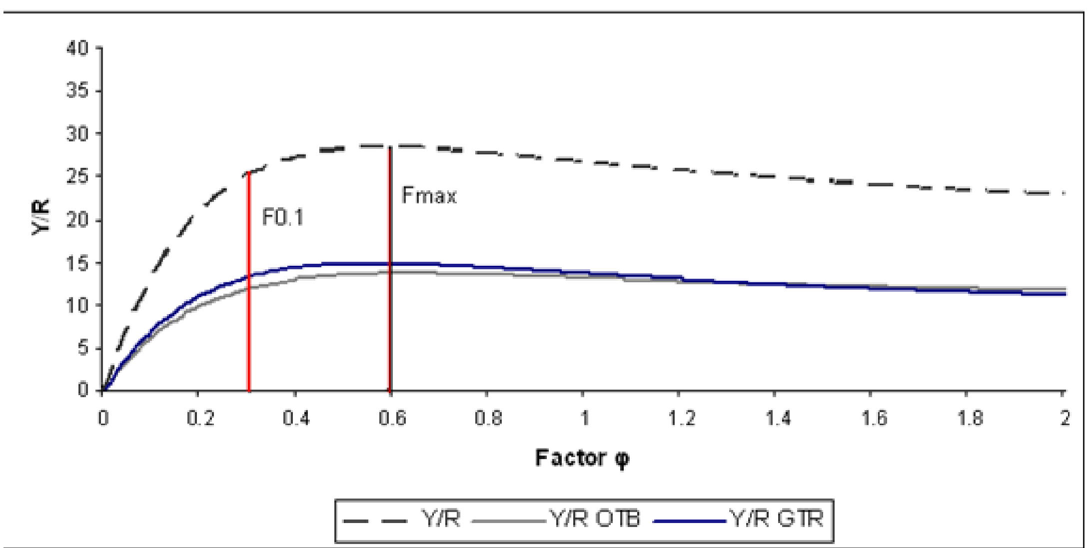


Fig. 5.30.5.1.1 Y/R analysis results.

A sensitivity analysis was carried out for investigating the sensitivity of Y/R results to changes in the input parameters (using the VIT software). Initially an automatic analysis was performed for each parameter with a factor increasing from 0.1 to 0.3. A sensitivity analysis followed on a combination of the VBGF parameters, as the results seem to be sensitive on these parameters. The results from the sensitivity analysis are provided in Table 5.30.5.1.2.

Tab. 5.30.5.1.2 Results from sensitivity analysis by VIT software on *M. barbatus* in GSA 25.

Combined parameters included in sensitivity analysis:	Linf
	k
Factor=0.1	t0

Parameters	Y/R	Biomass	SSB	Y/R Bottom trawl	Y/R Trammel net
'ooooooooo'	26.74	48.39	39.24	13.1	13.64
'-–oooooo'	14.06	24.46	20.2	6.87	7.2
'--+oooooo'	17.33	31.81	25.66	8.5	8.83
'-+-oooooo'	20.8	37.01	30.21	10.18	10.62
'-++oooooo'	25.2	47.41	37.8	12.39	12.81
'+–oooooo'	26.3	45.75	37.77	12.84	13.46
'+-+oooooo'	32.42	59.49	47.99	15.9	16.52
'++-oooooo'	38.91	69.21	56.49	19.05	19.86
'+++oooooo'	47.13	88.66	70.7	23.17	23.96

5.30.6. Scientific advice

5.30.6.1. Short term considerations

5.30.6.1.1. State of the spawning stock size

In the absence of proposed or agreed precautionary reference points SGMED 10-02 is unable to fully evaluate the status of the spawning stock size. In the current stock assessment no trend in the spawning stock biomass is evident.

5.30.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment as no trend in recruitment is evident.

5.30.6.1.3. State of exploitation

The estimated reference points of $F_{0.1}$ (0.22) and F_{max} (0.34), in relation with the estimated value of $F_{bar\ (1\text{-}3)}$ (=0.84), sugggest an overexploitation state of the stock in 2005 to 2008. SGMED-10-02 recommends a reduction in fishing effort of the relevant fleets until sustainable levels of fishing effort are achieved. This should be done by means of a multi-annual management plan taking into account mixed fisheries implications.

Given the assessment results, SGMED recommends $F_{0.1}$ of ages 1-3=0.22 be accepted as an approximation of F_{msy} and thus as the limit management reference of exploitation consistent with high long term yields.

5.31. Stock assessment of pink shrimp in GSA 01

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.31.1. Stock identification and biological features

5.31.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.31.1.2. Growth

Two sets of parameters were submitted to the meeting, obtained within the frame of the DCR call. These were for males and females combined, and GSA 01, GSA 05 and GSA 06 also combined. Growth parameters were estimated through length frequency analysis: "Slow" for the period 2005-2008 and "Fast" for the period 2002-2004.

Tab. 5.31.1.2.1 v. Bertalanffy growth parameters for the two options considered, fast and slow growth (data source: DCR).

	Linf (cm)	K	T0	Source
Fast	4.2	0.62	-0.08	Length freq. analysis
Slow	4.5	0.34	-0.06	Length freq. analysis

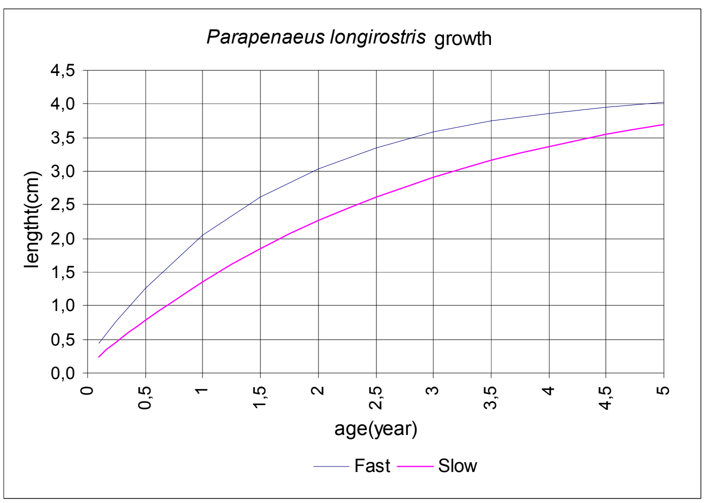


Fig. 5.31.1.2.1 Growth functions for the two fast and slow growth options.

Tab. 5.31.1.2.2 Length- weight relationship parameters, males and females combined.

a	b	
0.8142	2.6013	fast growth set
0.8148	2.61	slow growth set

5.31.1.3. Maturity

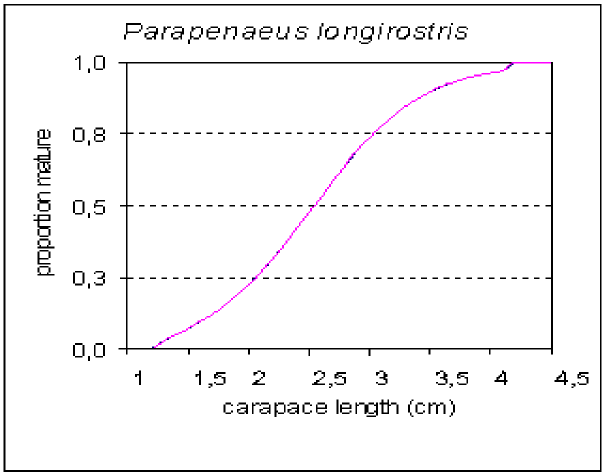


Fig. 5.31.1.3.1 Maturity ogive for males and females combined in GSA 01. Maturity stage determined macroscopically during the reproduction period (data source: DCR).

5.31.2. Fisheries

5.31.2.1. General description of fisheries

The bottom trawl fishery in GSA 01 is multispecies, targeting fish, cephalopods and crustaceans. Main target species are *Merluccius merluccius, Pagellus acarne, Octopus vulgaris* and *Parapenaeus longirostris.* Crustaceans get the highest values in the market representing 24% in the total catch, although *Nephrops norvegicus* and *Parapenaeus longirostris* contribute 6% to the total catch in weight. Fishing grounds are characterized by a narrow continental shelf, between 3 and 11 nautical miles wide (SEC(2004)772).

The species is found mainly at depths of between 140 and 400 m, i.e. on the continental shelf and in the upper slope on muddy or sandy muddy bottoms (Sbrana *et al.,* 2006).

5.31.2.2. Management regulations applicable in 2009 and 2010

Assumed to be the same regulations in force within the Spanish Mediterranean (5 fishing days a week; to be practiced at >50 depth; 12 hours at sea per day). In the last years a two-month closure has been implemented in the first half of the year.

5.31.2.3. Catches

5.31.2.3.1. Landings

Tab. 5.31.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. Since 2002 the annual landings decreased from 173 t to only 37 t in 2006 and remained low in 2007. In 2008 112 t of landings were reported while the 24 t reported in 2009 represent the minimum of the time series. The landings were only taken by demersal otter trawls.

Tab. 5.31.2.3.1.1 Annual landings (t) by fishing technique in GSA 01.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	1	ESP	OTB	DEMSP	40D50	173	123	117	81	37	58	112	24

5.31.2.3.2. Discards

Discards are not reported.

5.31.2.3.3. Fishing effort

No effort data were reported to SGMED-10-02 through the DCF data call for Spain.

5.31.3. Scientific surveys

5.31.3.1. Medits

5.31.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were calculated. In GSA 01 the following number of hauls was reported per depth stratum (s. Tab. 5.31.3.1.1.1).

Tab. 5.31.3.1.1.1. Number of hauls per year and depth stratum in GSA 01, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA01_010-050	2	1	2	2	2	2	2	3	3	3	3	2	3	3	4	2
GSA01_050-100	5	4	5	5	5	7	6	4	6	10	7	7	6	6	6	7
GSA01_100-200	3	3	3	5	5	5	5	4	8	6	5	6	5	6	6	6
GSA01_200-500	7	9	11	10	7	11	12	10	11	11	13	11	11	11	11	11
GSA01_500-800	6	9	12	10	12	12	9	13	13	14	13	11	15	10	7	5

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum

Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

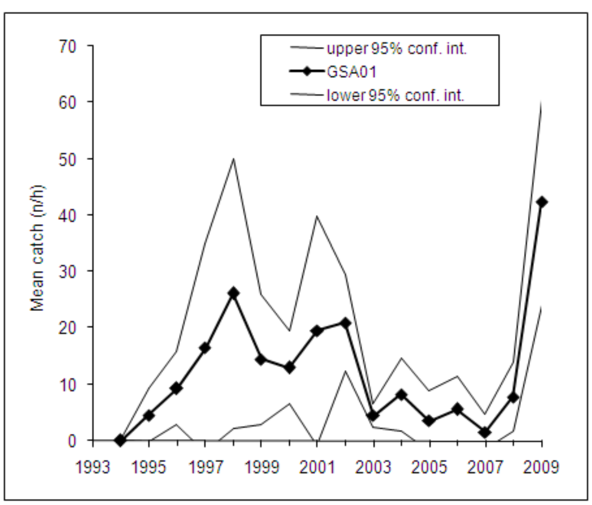
5.31.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.31.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the pink shrimp in GSA 01 was derived from the international survey Medits. Figure 5.31.3.1.3.1 displays the estimated trend in pink shrimp abundance and biomass in GSA 01.

The estimated abundance and biomass indices peaked in 1998 and decreased significantly until 2003. Since then, the indices varied at a low level while the estimated indices in 2009 represent the maximum values of the time series.



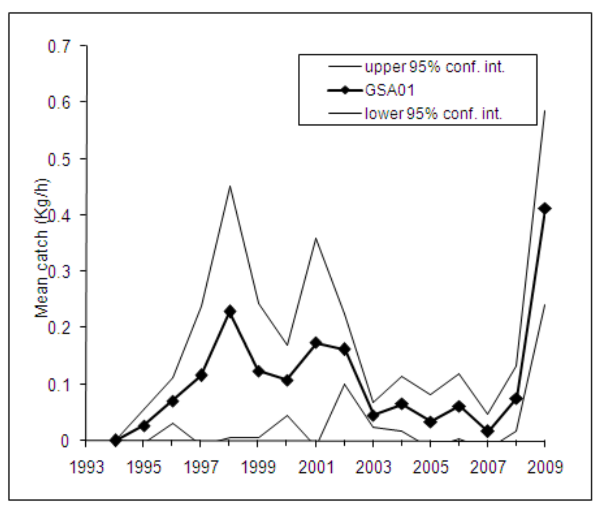


Fig. 5.31.3.1.3.1 Abundance and biomass indices of pink shrimp in GSA 01.

5.31.3.1.4. Trends in abundance by length or age

The following Fig. 5.31.3.1.4.1 and 2 display the stratified abundance indices of GSA 01 in 1995-2002 and 2003-2009. These size compositions are considered preliminary.

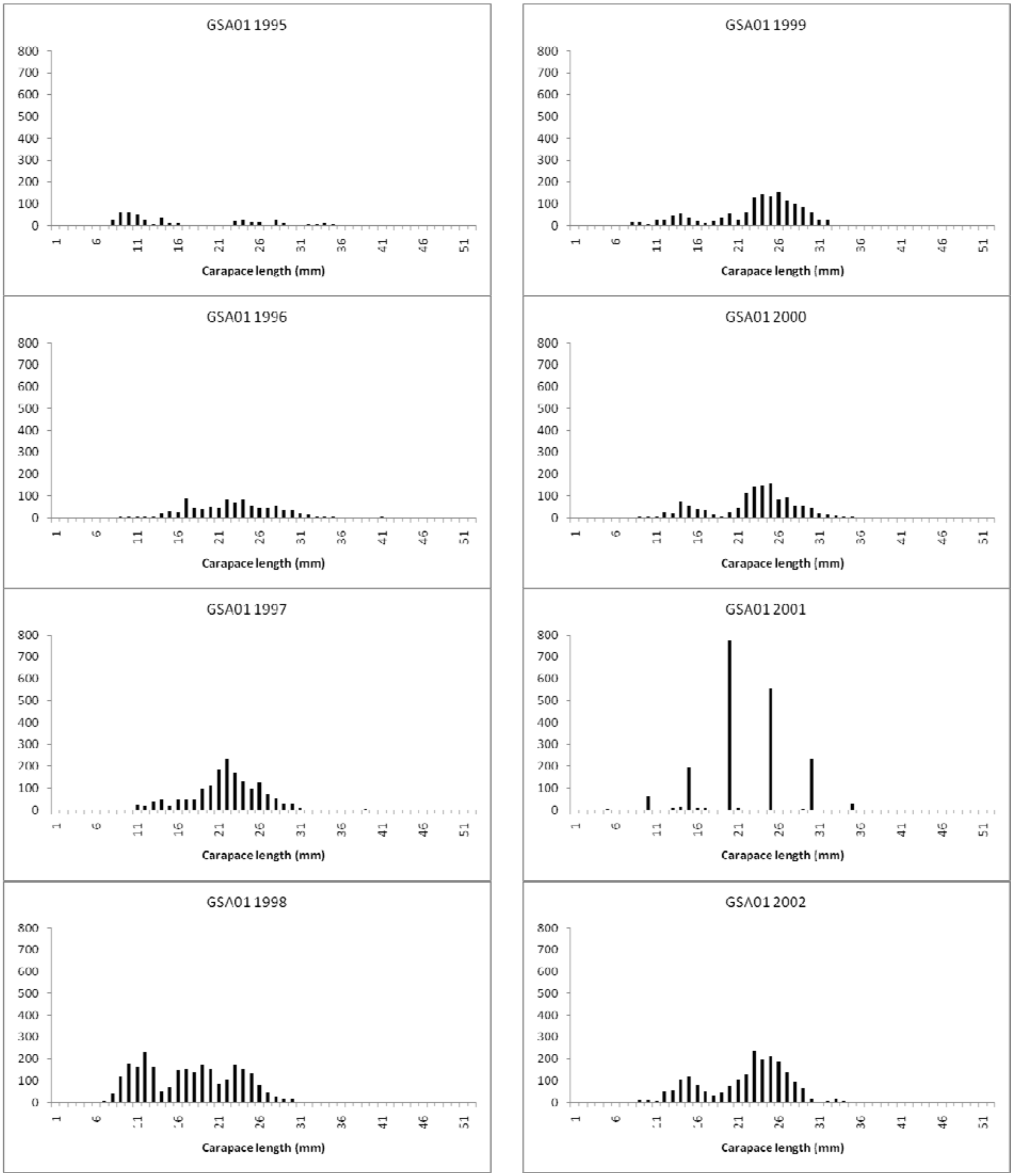


Fig. 5.31.3.1.4.1 Stratified abundance indices by size, 1995-2002.

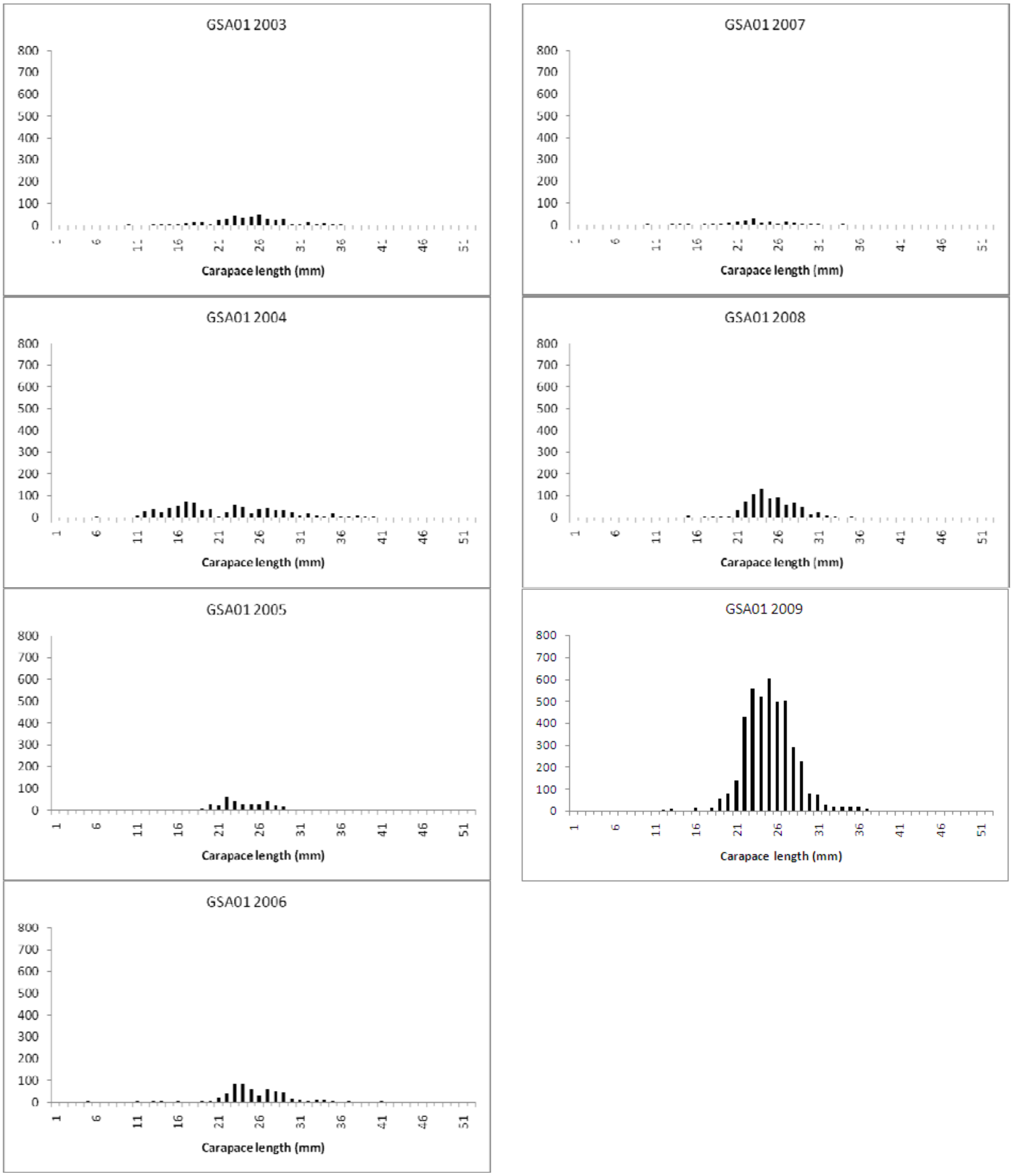


Fig. 5.31.3.1.4.2 Stratified abundance indices by size, 2003-2009.

5.31.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.31.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.31.4. Assessment of historic stock parameters

SGMED 10-02 did not undertake any analytical assessment of d in GSA 01. Latest assessment using SURBA and VIT can be found in the report of SGMED-08-04 working group (Cardinale et al., 2008).

5.31.5. Long term prediction

No update analyses were conducted during SGMED-10-02.

5.31.5.1. Justification

Yield per recruit analyses were conducted assuming equilibrium conditions.

5.31.5.2. Input parameters

Based on the exploitation pattern resulting from the VPA (VIT) and its population parameters, yield per recruit analyses were formulated.

5.31.5.3. Results

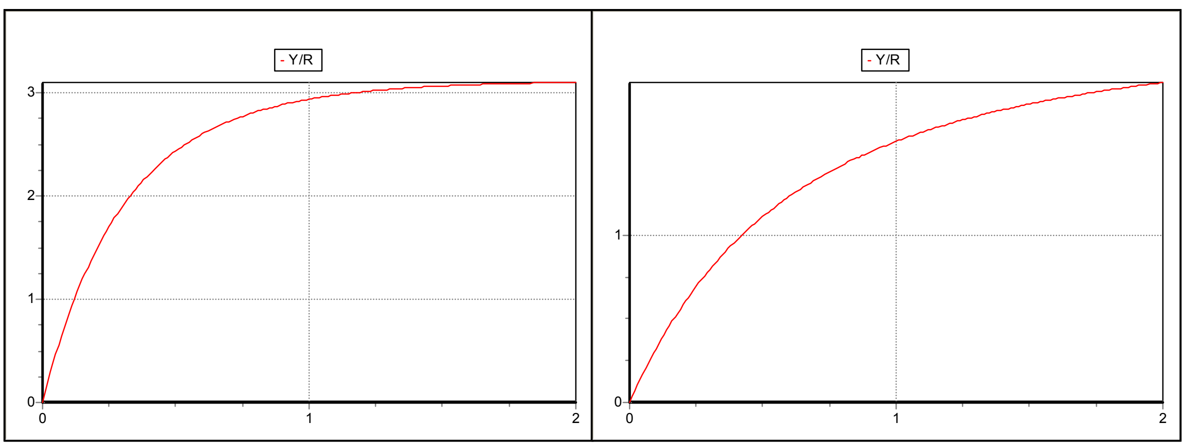


Fig. 5.31.5.3.1 Yield per recruit for fast (left) and slow growing scenarios (right) for the pink shrimp stock in GSA 01 (current effort).

Assuming equilibrium conditions, Fmax (F corresponding to the highest Y/R) seems to be in the region near the current F (F=1) in the fast growth scenario, or below it, in the slow growth scenario. Results suggest the stock would be in a situation near full exploitation in the fast growth scenario, where an increase in F would not result in an increase in Y/R, or underexploited in the case of slow growth scenario, where increasing F would lead to higher Y/R.

Because of the differences in growth, and under constant M, higher mean biomass and spawning stock biomass are needed in the case of slow growth scenario than in the fast growth, to sustain a given amount of landings. Also, current Fmean would be higher in the fast growth scenario.

SURBA results show decreasing F in the last years, when landings are at their lowest, and abundance and biomass indices from MEDITS are also low.

5.31.6. Scientific advice

5.31.6.1. Short term considerations

5.31.6.1.1. State of the spawning stock size

In the absence of proposed or agreed references SGMED-10-02 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them. SGMED notes that the abundance in 2009 represents the maximum of the time series since 1994.

5.31.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.31.6.1.3. State of exploitation

In the absence of proposed or agreed management reference points consistent with high long term yields SGMED-10-02 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them.

5.32. Stock assessment of pink shrimp in GSA 05

5.32.1. Stock identification and biological features

5.32.1.1. Stock Identification

Due to the lack of information about the structure of pink shrimp (*Parapenaeus longirostris*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 05 boundaries.

5.32.1.2. Growth

The following parameters were used (Guijarro et al., 2009):
L_∞ =31.3 (males) 44 (females)
k = 1.00 (males) 0.67 (females)
t_0= -0.49 (males) -0.21 (females)

Length-weight relationship:
a = 0.0024 (males) 0.0022 (females)
b = 2.5335 (males) 2.5626 (females)

5.32.1.3. Maturity

The maturity ogive used was the following (Guijarro *et al*., 2009):

AGE	0	1	2	3
REL.	0.22	0.83	1	1

5.32.2. Fisheries

5.32.2.1. General description of fisheries

In the Balearic Islands (GSA 05), commercial trawlers employ up to four different fishing tactics (Palmer et al., 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Guijarro & Massutí 2006; Ordines *et al*. 2006). Vessels mainly target striped red mullet (*Mullus sumuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered monospecific. The pink shrimp is caught as a by-catch in the upper slope.

5.32.2.2. Management regulations applicable in 2009 and 2010

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 HP: not fully observed
- Mesh size in the codend (diamond 40 mm stretched): fully observed
- Time at sea (12 hours per day and 5 days per week): fully observed
- Minimum landing size (EC regulation 1967/2006, 20 mm CL): mostly fully observed

5.32.2.3. Catches

5.32.2.3.1. Landings

Landings of pink shrimp in GSA 05 come exclusively from the trawling fleet. In the last 10 years they have presented important oscillations, from maximum landings around 50 t (in 2001) to minimum landings of less than 1 t in 2006-2007. However, it seems than from 2008, the landings have started to increase again (Fig. 5.32.2.3.1.1).

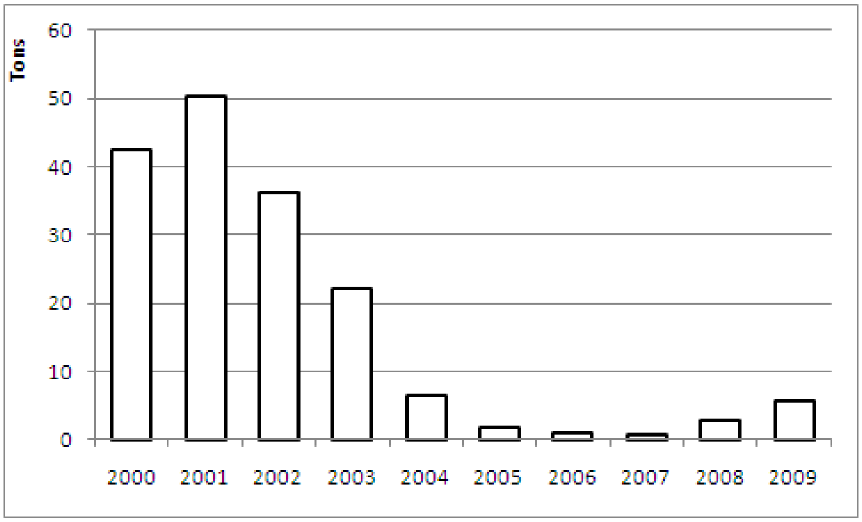


Fig. 5.32.2.3.1.1 Landings of pink shrimp (trawling) in the GSA 05, from 2000 to 2009.

Landings are mostly composed by specimens from 23 to 35 mm CL in the case of females and from 19 to 29 mm CL in the case of males (90% of the catches, Fig. 5.32.2.3.1.2).

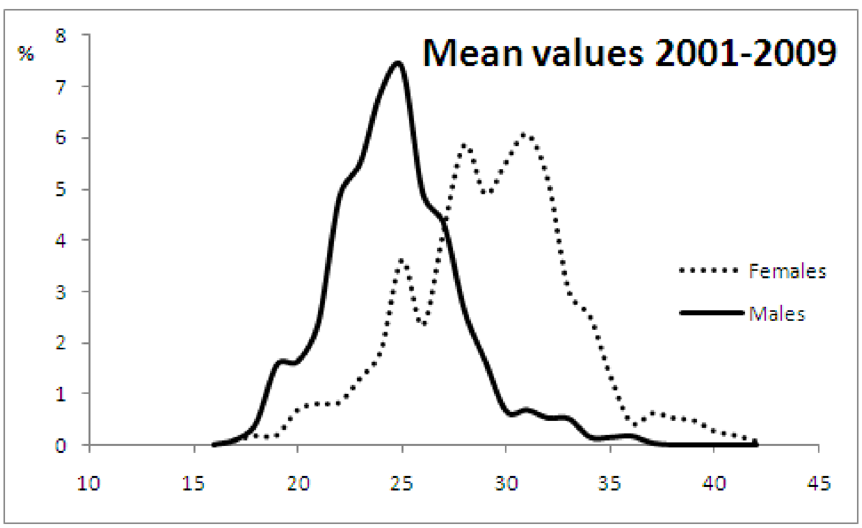


Fig. 5.32.2.3.1.2 Size structure of the landings of *P. longirostris* in 2001-2009 (mean value) caught by otter trawling in the GSA 05.

Tab. 5.32.2.3.1.1 Landings of pink shrimp (in tons, trawling) in the GSA 05 as reported through the official DCF data call 2010, from 2002 to 2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	5	ESP	OTB	DEMSP	40D50	36	22	6	2	1	1	3	6

5.32.2.3.2. Discards

Discard of pink shrimp in GSA 05 can be considered as negligible.

5.32.2.3.3. Fishing effort

Although there was a progressive diminution in the number of trawlers during the period 2000-2008, the total fishing effort remained rather constant because of the increase in vessel mean power (Fig. 5.32.2.3.3.1).

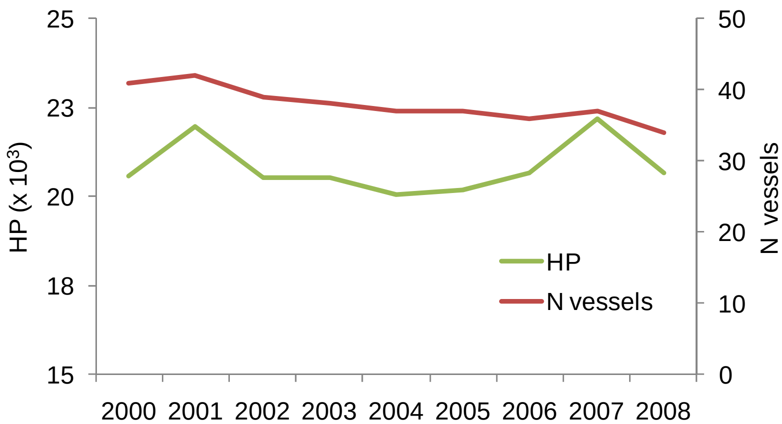


Fig. 5.32.2.3.3.1 Number of trawlers and total HP (mean HP x N of vessels) in Mallorca during 2000-2008.

No effort data were reported through the official DCF data call 2010.

5.32.3. Scientific surveys

5.32.3.1. BALAR and MEDITS surveys

5.32.3.1.1. Methods

From 2001, the Spanish Institute of Oceanography has performed annual bottom trawl surveys following the same methodology and sampling gear described in the MEDITS protocol.

5.32.3.1.2. Geographical distribution patterns

Parapenaeus longirostris from GSA 05 is mainly distributed in the southern and northwestern of Mallorca (Fig. 5.32.3.1.2.1, Guijarro *et al*., 2009).

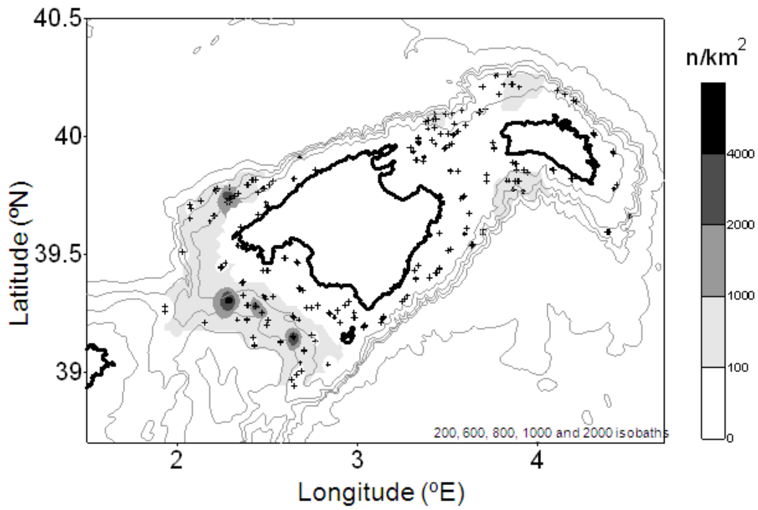


Fig. 5.32.3.1.2.1 Distribution of *P. longirostris* in the GSA 05 from the BALAR (2001-2006) and MEDITS surveys (2007-2008).

5.32.3.1.3. *Trends in abundance and biomass*

Fig. 5.32.3.1.3.1 shows the abundance and biomass of pink shrimp from the BALAR and MEDITS surveys. They show oscillations with a peak in 2001-2002 and minimum values during 2005-2007. However, during the last two years it seems that there is a small increase in both abundance and biomass.

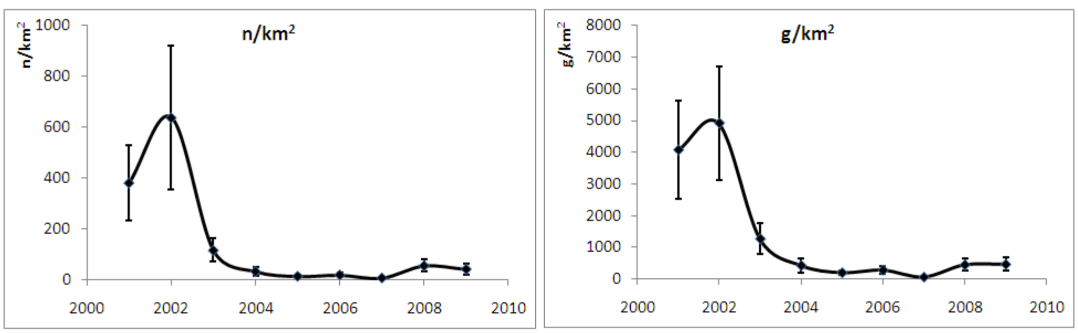


Fig. 5.32.3.1.3.1 Abundance and biomass indices of *Parapenaeus longirostris* in GSA 05 from BALAR and MEDITS surveys.

5.32.3.1.4. *Trends in abundance by length or age*

No analyses were conducted during SGMED-10-02.

5.32.3.1.5. *Trends in growth*

No analyses were conducted during SGMED-10-02.

5.32.3.1.6. *Trends in maturity*

No analysis were conducted during SGMED-10-02.

5.32.4. *Assessment of historic stock parameters*

Pink shrimp from GSA05 has never been assessed before, neither in the framework of SGMED nor in the framework of GFCM so this can be considered the first assessment of this stock.

5.32.4.1. Method 1: XSA

5.32.4.1.1. Justification

The length of the data series available (9 years, from 2001 to 2009) allowed the use of a VPA tuned with fishery independent data (XSA), from the BALAR-MEDITS surveys. The software used was the Lowestoft suite (Darby and Flatman, 1994). A separable VPA (Pope and Sheperd, 1982) was also used as exploratory analysis.

5.32.4.1.2. Input parameters

Landings time series from 2001 to 2009 from the bottom trawl fleet of Mallorca.
Length frequency distributions from monthly on board samplings developed between 2001 and 2009 (Fig. 5.32.4.1.2.1).

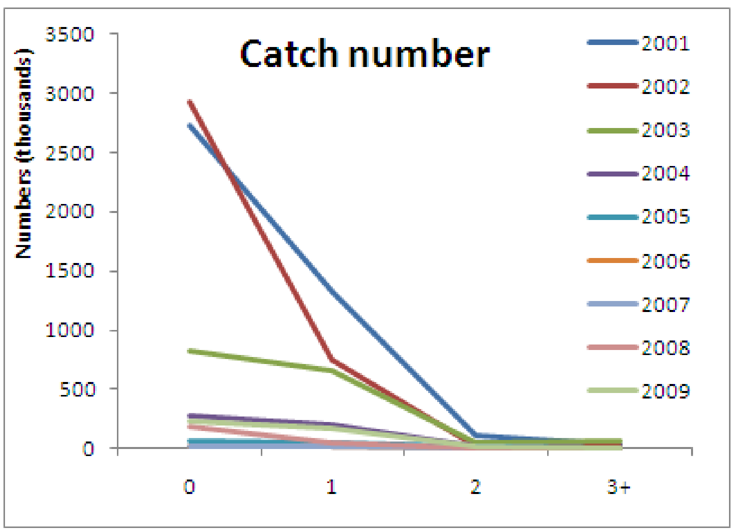


Fig. 5.32.4.1.2.1 Age distributions of pink shrimp in the Balearic Islands, by year.

The biological parameters used for the assessment are shown in the following tables (Guijarro et al., 2009). Natural mortality at age was calculated using the PROBIOM spreadsheet (Abella *et al*., 1997).

Sex	Growth parameters		
	L_8	k	t_0
F	44 mm	0.67 y^{-1}	-0.21 y
M	31.3 mm	1.00 y^{-1}	-0.49 y

Sex	Length-weight relationship	
	a	b
F	0.0022	2.5626
M	0.0024	2.5335

Maturity ogive				
Age	0	1	2	3
Prop. Matures	0.22	0.83	1.0	1.0

Natural mortality				
Age	0	1	2	3
F	0.872	0.289	0.184	0.137
M	0.840	0.447	0.271	0.168
F+M	0.850	0.454	0.276	0.173

Terminal fishing mortality (Ft) was obtained from the catch curve, using the FLEDA package (Jardim & Azevedo, 2004).

Table 5.32.4.1.2.1 Landings at age (thousands), 2001-2009.

	0	1	2	3
2001	2733.8	1321	107.9	40
2002	2924.3	750.2	16.2	15.9
2003	822.3	656.2	43.7	71.2
2004	281.7	195.3	18.2	3.5
2005	59.2	44	12.3	3.5
2006	24.8	25.1	7.6	1.7
2007	24.1	21.5	3	0.6
2008	181.6	55.4	5	1.3
2009	231.3	178	12.1	2.6

Table 5.32.4.1.2.2 Tuning indices at age from the BALAR-MEDITS surveys, 2001-2009.

	0	1	2	3
2001	257.3	117.1	6.9	0.6
2002	454.5	59.1	5.5	2.3
2003	86.8	26.4	2.1	0.3
2004	15.5	15.6	2	0.4
2005	7.7	4.8	1.9	0.4
2006	9.7	5.4	3.8	1
2007	6.5	1.3	0.4	0
2008	50.7	4	1.1	0
2009	27.5	13.5	1.2	0.3

5.32.4.1.3. *Results*

Table 5.32.4.1.3.1 Tuning settings and diagnostics from the XSA.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
0	1.02	-0.075	-1.9	0.79	9	0.76	1.78
1	0.92	0.432	1.28	0.83	9	0.69	-0.94
2	0.81	1.306	0.78	0.88	9	0.44	-0.2
3	1.99	-2.686	-0.58	0.53	9	1.44	-0.7

Table 5.32.4.1.3.2 Estimated fishing mortalities at age as derived from the XSA, 2001-2009.

AGE	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	1.0061	1.1643	1.0879	1.2696	0.6506	0.3096	0.1448	0.3498	0.5921
1	2.1815	2.4507	2.9779	2.2751	1.4579	1.3701	0.9261	1.1634	1.5501
2	1.5852	0.1495	2.1993	1.3665	1.5697	1.7165	0.7042	0.7149	1.1789
3	1.6271	1.2576	2.1802	1.6292	1.2148	1.0737	0.5998	0.8084	1.1381

Table 5.32.4.1.3.3 Estimated stock numbers at age as derived from the XSA, 2001-2010.

AGE	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	6592	6503	1897	599	189	142	273	941	792	0
1	1869	1030	868	273	72	42	45	101	284	187
2	156	134	56	28	18	11	7	11	20	38
3	54	24	88	5	5	3	1	3	4	5

Table 5.32.4.1.3.4 Stock summary table as derived from the XSA, 2001-2009.

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 0- 3
	Age 0						
2001	6592	96	44	50	1.1494	1.019	1.6
2002	6503	73	29	36	1.2609	1.0212	1.2555
2003	1897	37	20	22	1.1124	0.9939	2.1113
2004	599	11	6	6	1.129	0.992	1.6351
2005	189	3	2	2	0.8523	0.9669	1.2232
2006	142	2	1	1	0.7283	1.007	1.1175
2007	273	4	1	1	0.4837	0.9541	0.5937
2008	941	11	4	3	0.756	1.0114	0.7591
2009	792	13	6	6	0.9015	1.0048	1.1148

Fig. 5.32.4.1.3.1 shows the main XSA results. Both stock abundance and biomass show a maximum at the beginning of the period, with minimum values around 2005-2006 and a slight increasing trend since then. Number of recruits and spawning stock biomass show the same trend. Fishing mortality shows the highest value in 2003 and minimum in 2007, with an increasing trend since then.

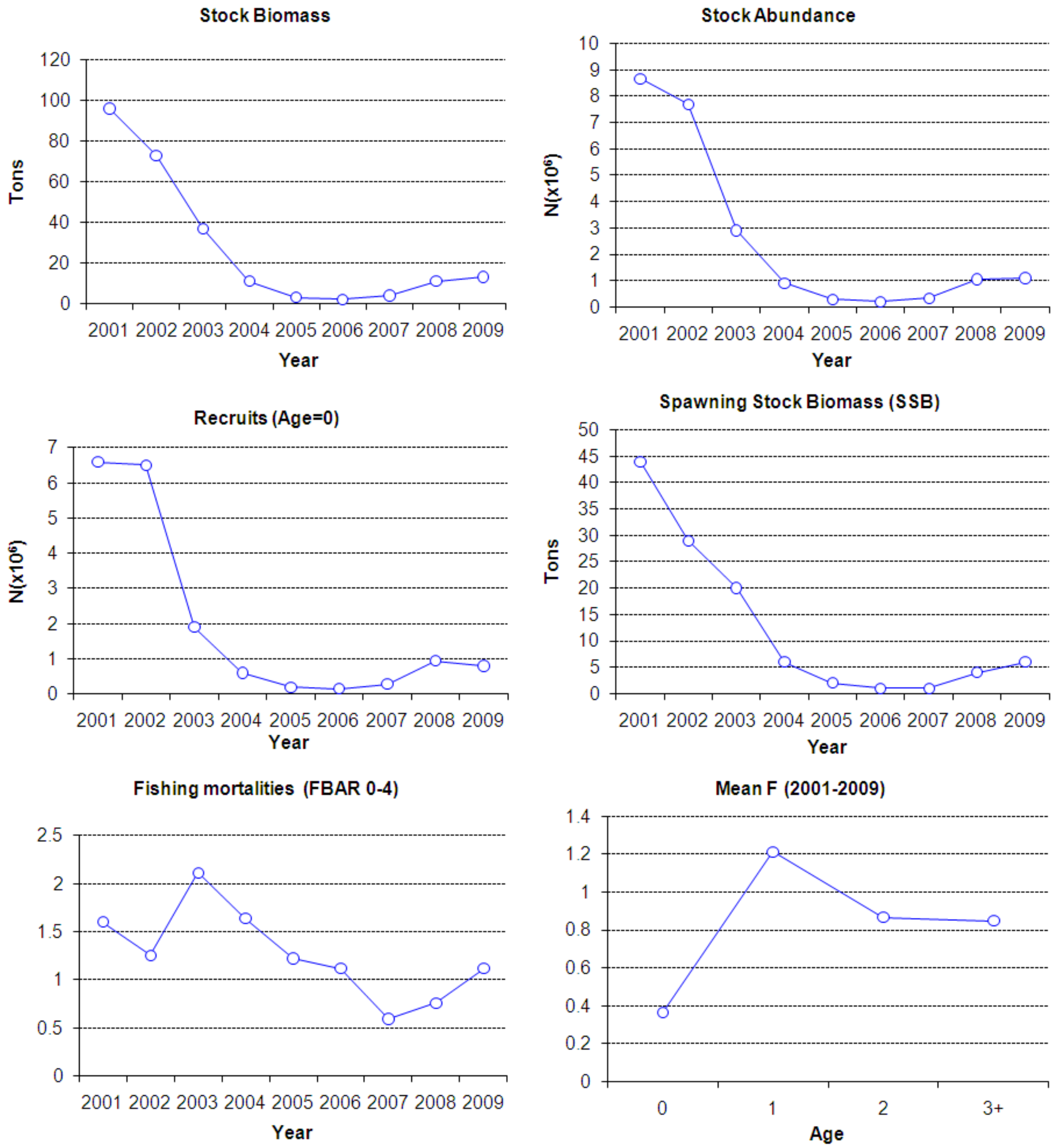


Fig. 5.32.4.1.3.1 Main assessment results: stock abundance and biomass, number of recruits, spawning stock biomass and fishing mortalities by year and age for *P. longirostris* in GSA 05.

5.32.5. Long term prediction

5.32.5.1. Justification

A yield per recruit analysis was conducted.

5.32.5.2. Input parameters

Yield per recruit analysis was conducted based on the exploitation pattern resulting from the XSA model and population parameters. Minimum and maximum ages for the analysis were 0 and 3 years, respectively. Stock weight at age and catch weight at age were estimated as mean values on a long term basis (2001-2009).

Natural mortality by age were from PROBIOM (Abella et al., 1997). Fishing mortalities from 2009 were used. Reference F was considered to be mean F for ages 0 to 3.

Table 5.32.5.2.1 Yield per recruit input parameters.

Age group	Stock weight	Catch weight	Maturity	F	M
0	0.010	0.010	0.22	0.36	0.85
1	0.017	0.017	0.83	1.21	0.45
2	0.022	0.022	1	0.86	0.28
3	0.026	0.026	1	0.84	0.17

5.32.5.3. Results

The reference fishing mortality (F_{ref}) is displayed in the following table, along with the reference points $F_{0.1}$ and F_{max}. Fig. 5.32.5.3.1 shows the results of the yield per recruit analysis.

	F
$F_{0.1}$	0.31
F_{max}	2.22
F_{ref}	1.11

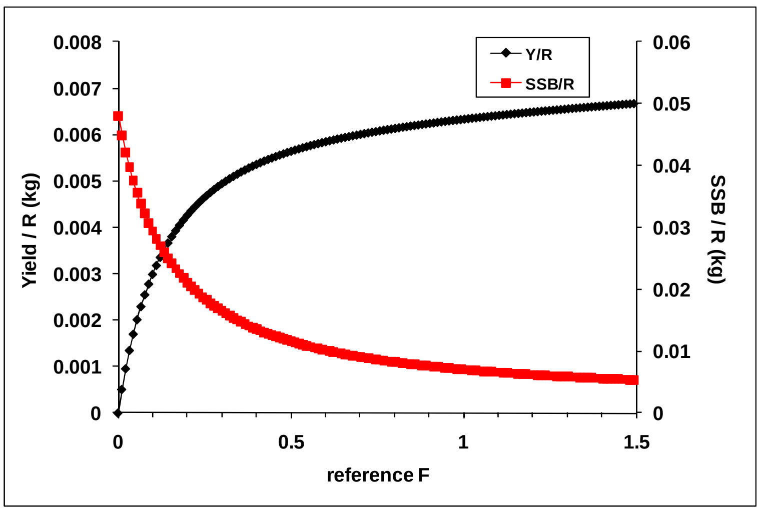


Fig. 5.32.5.3.1 Results of the yield per recruit analysis showing the Y/R and SSB/R.

5.32.6. Data quality

Data from Spain was not submitted on time through the Official Data call but only sent by email later on and therefore not accepted. The assessment was carried out with data from the Spanish Data Collection Program.

5.32.7. Scientific advice

5.32.7.1. Short term considerations

5.32.7.1.1. State of the spawning stock size

SSB showed a progressive decreasing trend throughout the series; the number of tons decreased from 45 tons in 2001 to less than 5 tons in 2005-2007. However, SSB has slightly increased in 2008 and 2009. In the absence of proposed or agreed precautionary management reference points SGMED is unable to fully evaluate the state of the SSB.

5.32.7.1.2. State of recruitment

Recruitment showed a constant value for the first two years of the series (around 6.5 millions) and a significant decrease in 2003. Recruitment continued to be very low during the following years. However, recent recruitment in 2008 and 2009 has increased slightly.

5.32.7.1.3. State of exploitation

SGMED proposed $F_{0.1}$=0.31 as limit management reference point for exploitation consistent with high long term yields. Fishing mortality showed oscillations during the entire data series, with the maximum values in 2003 and minimum in 2008. The vector of fishing mortality by age depictures a typical selection curve and shows that the highest fishing exploitation is suffered by 1-year-old individuals and also that the exploitation of the recruits (age 0) is very low. The F_{ref} (0.82) exceeds the Y/R $F_{0.1}$ reference point (0.31), which indicates that pink shrimp in GSA 05 is overexploited.

Although the stock is overexploited, it is important to remark than the oscillations found for this species are in agreement with other areas of the Mediterranean and probably caused not only by fishing mortality but also by environmental changes.

5.33. Stock assessment of pink shrimp in GSA 06

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.33.1. Stock identification and biological features

5.33.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.33.1.2. Growth

SGMED-10-02 notes that the set of growth parameters used in the assessment were different to those used in previous years, and a set more in agreement with the "slow growth hypothesis" has been followed. Growth parameters used were those from Garcia-Rodriguez et al. (2009) over length distributions analysis (Linf= 45.0; K = 0.39; t_0= 0.1019), and length-weight relationship (a= 0.0019; b= 2.611).

5.33.1.3. Maturity

Maturity ogive was taken from García Rodriguez *et al*. (2009), with size at first maturity (50%) at 25.65 mm CL.

Tab. 5.33.1.3.1 Maturity ogive for pink shrimp in GSA 06.

Age class	0	1	2	3	4	5	6	7
Maturity ratio	0	0.1343973	0.5044019	0.7877772	0.9015605	0.9738161	1	1

5.33.2. Fisheries

5.33.2.1. General description of fisheries

Deep-water pink shrimp (*Parapenaeus longirostris*) is one of the most important crustacean species for the trawl fisheries developed along the GFCM geographical sub-area Northern Spain (GSA 06). This resource is an important component of commercial landings in some ports of the Mediterranean Northern Spain and occasionally target species of the trawl fleet, composed by around 600 vessels, and especially by 260 vessels which operate on the upper slope.

5.33.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.33.2.3. Catches

5.33.2.3.1. Landings

During the last years, a sharp increase in landings was observed, starting in 1998 and reaching the maximum value in 2000, followed by a decreasing trend during the period 2001-2008. In 2008 the annual landings of this species amounts 33 tons in the whole area, which represents the lowest value of the historical series.

Tab. 5.33.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported through the Data Collection Regulation. Since 2002 the annual landings decreased from 380 t to only 33 t in 2008. In 2009, the landings continued to be low with 54 t. The landings were only taken by demersal otter trawls.

Tab. 5.33.2.3.1.1 Annual landings (t) of deep-water pink shrimp by fishing technique in GSA 06 as reported throught the official DCF data call in 2010.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	6	ESP	OTB	DEMSP	40D50	380	190	117	63	49	41	33	54

5.33.2.3.2. Discards

No information was documented during SGMED-10-02.

5.33.2.3.3. Fishing effort

Fishing effort has reduced from 50,000 days in 2000 to 13,000 in 2006, with a slight increase in 2007 and 2008 to 18,000. SGMED-10-02 notes that this fishing effort includes vessels that have landed pink shrimp in the given years. No official data have been reported to SGMED-10-02.

5.33.3. Scientific surveys

5.33.3.1. MEDITS

5.33.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 06 the following number of hauls were reported per depth stratum (s. Tab. 5.33.3.1.1.1).

Tab. 5.33.3.1.1.1. Number of hauls per year and depth stratum in GSA 06, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA06_010-050	7	8	7	7	7	8	9	8	11	9	9	11	11	6	7	6
GSA06_050-100	19	26	26	26	28	29	29	31	36	38	31	32	34	40	43	41
GSA06_100-200	11	17	17	15	13	17	18	20	20	21	17	18	19	24	30	30
GSA06_200-500	10	12	10	12	7	13	12	16	17	18	16	15	18	18	19	19
GSA06_500-800	6	8	9	7	4	9	6	8	7	11	11	8	10	15	13	13

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.33.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.33.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the pink shrimp in GSA 06 was derived from the international survey Medits. Figure 5.33.3.1.3.1 displays the estimated trend in pink shrimp abundance and biomass in GSA 06.

The estimated abundance and biomass indices were high in 2000 and 2001 but varied at a low level until 2008. In 2009, both abundance and biomass has increased significantly.

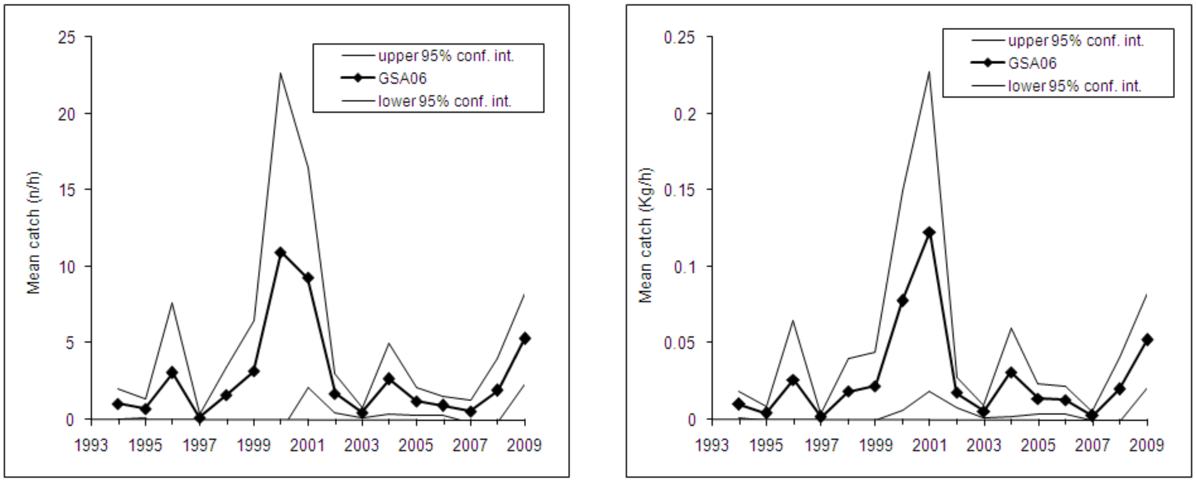


Fig. 5.33.3.1.3.1 Abundance and biomass indices of pink shrimp in GSA 06.

5.33.3.1.4. Trends in abundance by length or age

The following Fig. 5.31.3.1.4.1 and 2 display the stratified abundance indices of GSA 06 in 1994-2001 and 2002-2009.

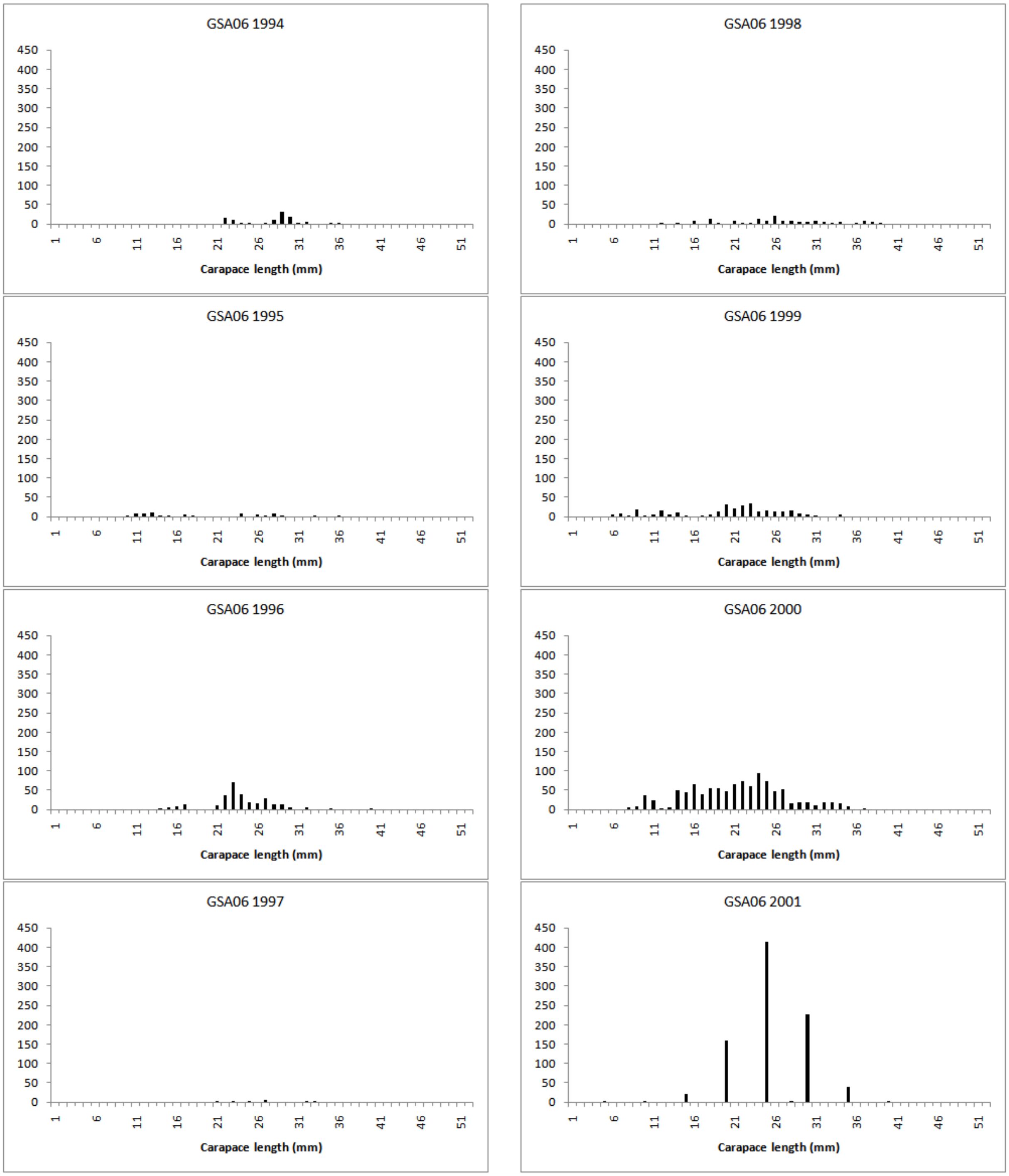


Fig. 8.31.3.1.4.1 Stratified abundance indices by size, 1994-2001.

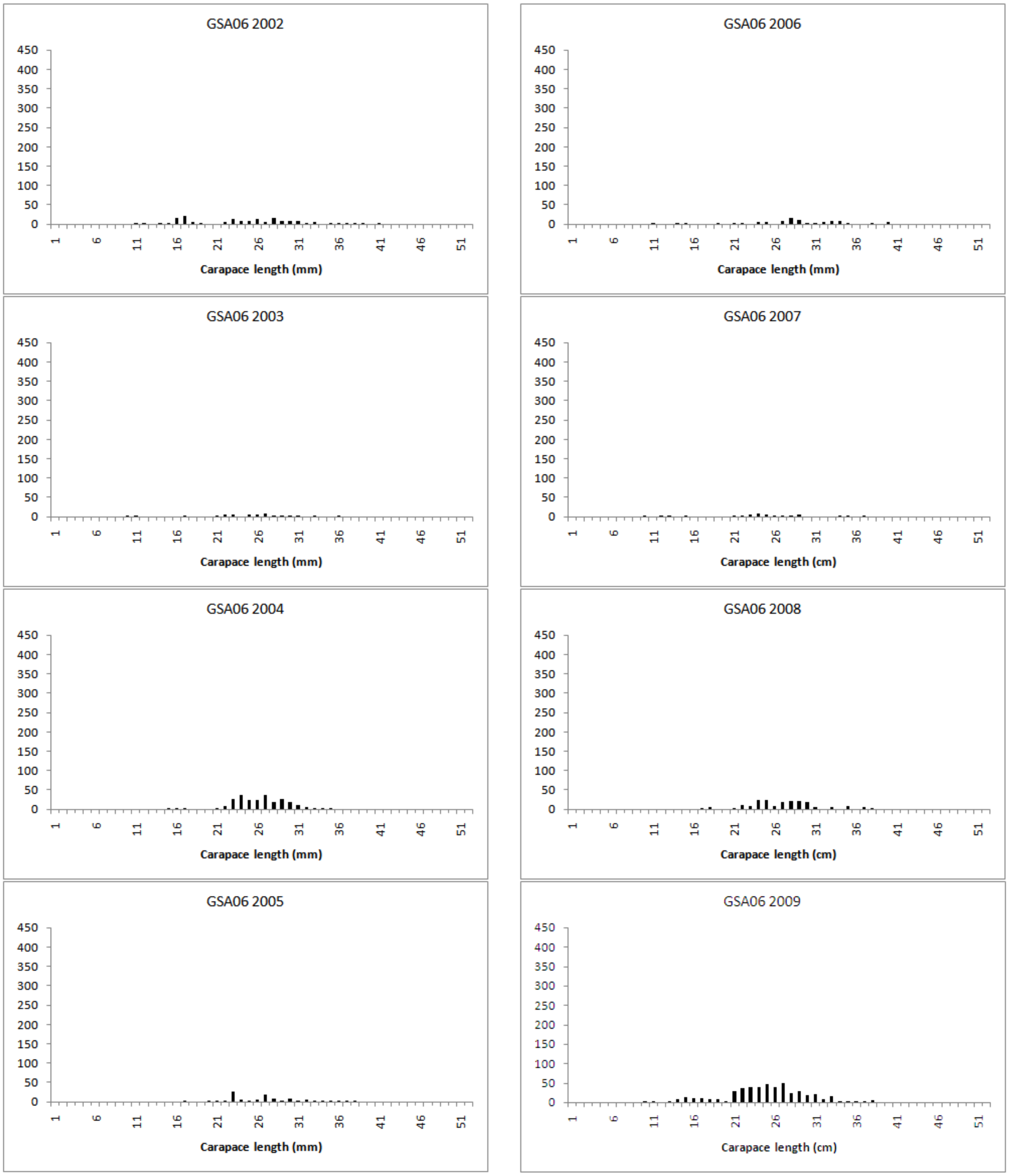


Fig. 5.33.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.33.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.33.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.33.4. Assessment of historic stock parameters

5.33.4.1. Method 1: XSA

The following assessment was not updated during SGMED-10-02 in 2010.

5.33.4.1.1. Justification

During the SGMED-09-02, an assessment on pink shrimp from GSA 06 was performed applying XSA. Files dealing with official landings and effort were not available in2009.

5.33.4.1.2. Input parameters

The following Table 5.33.4.1.2.1 lists the various input parameters at age.

Tab. 5.33.4.1.2.1 XSA input parameters.

Pink shrimp GSA 06			Catch at age				
Age class	2002	2003	2004	2005	2006	2007	2008
0	13	0.8	3.2	0	0	0	0
1	19506.9	4371.1	3970.5	1256.5	673.5	687.8	912.8
2	18438.2	8368.2	5369	2835.4	1888.4	2109	1854.5
3	4429	3589.3	2103.8	1131.2	588.7	598.6	295.6
4	596.3	601	200.9	212	180	168.1	70.1
5	54.6	81.7	26.5	51.8	44.5	73.8	12.8
6	8.1	13.3	2.5	15.9	9.6	21.4	4.6
7	0.2	0.4	0.1	4.4	4.9	4.7	0.7
8+	0	0	0	0.3	0.4	0.4	3.5

			Weight at age (kg)				
Age class	2002	2003	2004	2005	2006	2007	2008
0	0.002	0.002	0.001	0	0	0	0
1	0.006	0.005	0.006	0.006	0.006	0.006	0.006
2	0.01	0.011	0.01	0.01	0.01	0.01	0.01
3	0.017	0.017	0.017	0.017	0.017	0.017	0.017
4	0.022	0.022	0.023	0.023	0.023	0.023	0.022
5	0.027	0.027	0.027	0.027	0.027	0.028	0.028
6	0.031	0.031	0.031	0.031	0.031	0.031	0.031
7	0.032	0.032	0.032	0.034	0.034	0.034	0.033
8+	0	0	0	0.034	0.034	0.034	0.036

Age class	Maturity at age	Age class	Natural mortality
0	0	0	1.25
1	0.1343973	1	1.25
2	0.5044019	2	1.25
3	0.7877772	3	1.25
4	0.9015605	4	1.25
5	0.9738161	5	1.25
6	1	6	1.25
7	1	7	1.25
8+	1	8+	1.25

			Tunning parameters (MEDITS)				
Age class	2002	2003	2004	2005	2006	2007	2008
0	0.000597	0.000414	0	0	0.000068	0.000424	0
1	0.034812	0.004609	0.018124	0.010526	0.038326	0.009121	0.005283
2	0.214594	0.015352	0.189164	0.042187	0.12773	0.059118	0.04069
3	0.048323	0.004198	0.044402	0.033843	0.02891	0.024405	0.007893
4	0.006992	0.003313	0.001132	0.010925	0.004459	0.016246	0.006915
5	0.004155	0	0	0.002983	0.006564	0	0.001019
6	0.003048	0	0	0	0.004226	0.003888	0
7	0.000173	0	0	0	0	0.000221	0

5.33.4.1.3. Results

Tab. 5.33.4.1.3.1 Estimated fishing mortality at ages 0-8, 2002-2008.

Table 8	Fishing mortality (F) at age						
YEAR	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**FBAR ****
AGE								
0	0.0001	0	0	0	0	0	0	0
1	0.2072	0.0765	0.1235	0.0518	0.0388	0.0406	0.0483	0.0426
2	0.601	0.4226	0.4168	0.3969	0.3267	0.5661	0.4947	0.4625
3	0.6318	0.8206	0.6189	0.4785	0.4355	0.5576	0.466	0.4864
4	0.5496	0.54	0.2856	0.3586	0.4168	0.785	0.364	0.5219
5	0.7332	0.4313	0.1168	0.3532	0.3799	1.3468	0.3811	0.7026
6	1.5196	2.5229	0.0593	0.3002	0.3202	1.4944	0.9648	0.9265
7	0.8666	0.9555	0.3579	0.4707	0.4727	1.0353	0.5019	0.67
+gp	0.8666	0.9555	0.3579	0.4707	0.4727	1.0353	0.5019	
0 FBAR 2- 5	0.6289	0.5536	0.3595	0.3968	0.3897	0.8139	0.4265	

Tab. 5.33.4.1.3.2 Summary of estimated stock parameters, 2002-2008.

Table 17	Summary (with SOP correction)						
	Terminal Fs derived using XSA (With F shrinkage)						
	RECRUIT!	**TOTALBIO**	**TOTSPBIO**	**LANDINGS**	**YIELD/SSB**	**SOPCOFAC**	**FBAR 2- 5**
	Age 0						
2002	387022	2979	812	380	0.4682	0.9704	0.6289
2003	222891	1767	550	190	0.3454	0.9959	0.5536
2004	162431	1019	355	117	0.33	0.9857	0.3595
2005	115435	588	237	63	0.2656	1.0153	0.3968
2006	112647	520	206	49	0.2384	1.267	0.3897
2007	126322	340	123	41	0.3341	0.9724	0.8139
2008	202213	361	111	33	0.2962	1.05	0.4265
Arith.							
Mean	189852	1082	342	125	0.3254		0.5098
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

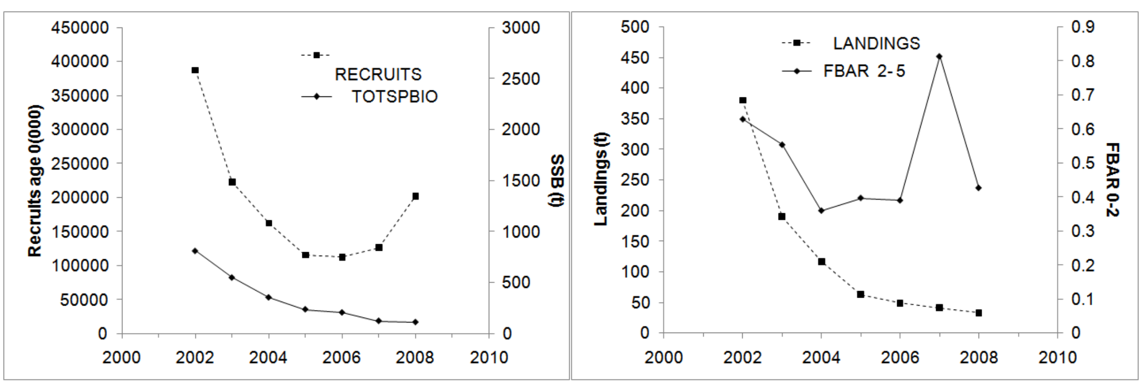


Fig. 5.33.4.1.3.1 Estimated trends in spawning stock biomass SSB, recruits and mean fishing mortality at ages 2-5.

5.33.5. Long term prediction

5.33.5.1. Justification

No forecast analyses were conducted.

5.33.5.2. Input parameters

No forecast analyses were conducted.

5.33.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for pink shrimp in GSA 06.

5.33.6. Scientific advice

5.33.6.1. Short term considerations

5.33.6.1.1. State of the spawning stock size

Since 2002, SSB, with an average for the whole period of 342 tons, declined rapidly and continuously to the lowest value observed in 2008 (111 mt) which represents only 8% of that observed in 2002. SGMED notes that the MEDITS survey abundance index shows a very high peak in abundance in the 1999-2001 period, which represents the start of the assessment period. Prior to 1999, abundance levels were comparable to those seen in the 2002-2008 period. However, the 2009 indices of stock size reveal a significant increase. SGMED cannot evaluate the state of the spawning stock relative to management reference points, as these have not been proposed or defined.

5.33.6.1.2. State of recruitment

Recruits (aged 0 individuals) were estimated to have declined from 2002 to 2005 in the same pattern as SSB and continued to be very low in 2006-2007. However, in 2008, recruitment increased significantly and appears to be at the level of the 2003 value. Such increased recruitment seems to have contributed to some recovery of the stock in short time as indicated by the survey results in 2009.

5.33.6.1.3. State of exploitation

Fishing mortality over ages 2-5 displays a high variation with an average value of 0.5. SGMED 10-02 is unable to fully evaluate the exploitation status as no limit management reference points consistent with high long term yields have been estimated.

F and effort should be kept at a low level to allow any strong future recruitments to rebuild the stock. SGMED recommends a recovery plan to be established for this stock that takes into account the mixed species nature of the fishery.

5.34. Stock assessment of pink shrimp in GSA 09

5.34.1. Stock identification and biological features

5.34.1.1. Stock Identification

Due to a lack of information about the structure of pink shrimp population in the western Mediterranean, this stock was assumed to be confined within the GSA 09 boundaries.

The species shows a wide bathymetric distribution in the GSA 09, being present from 50 to 650 m depth with greatest abundance between 150 and 400 m depth over muddy or sandy-muddy bottoms (Ardizzone and Corsi, 1997; Biagi *et al.*, 2002).

The highest abundances have been found in the Tyrrhenian part of the GSA (south Tuscany and Latium).

Recruits (CL ≤ 15 mm) occur all year round with a main peak from July to October (De Ranieri *et al.*, 1997). The main nurseries revealed a high spatio-temporal persistency (Fig. 5.34.1.1.1) between 60 and 220 m depth. The core of nursery areas overlap with crinoid beds (*Leptometra phalangium*) areas over the shelf-break (Colloca *et al.*, 2004, 2006a; Reale *et al.*, 2005). This is a peculiar habitat in the GSA 09 which is also an essential fish habitat for other commercially important species as the European hake, *Merluccius merluccius*. A positive size-depth distribution was found with an increased abundance of larger females with depth (Ardizzone *et al.*, 1990).

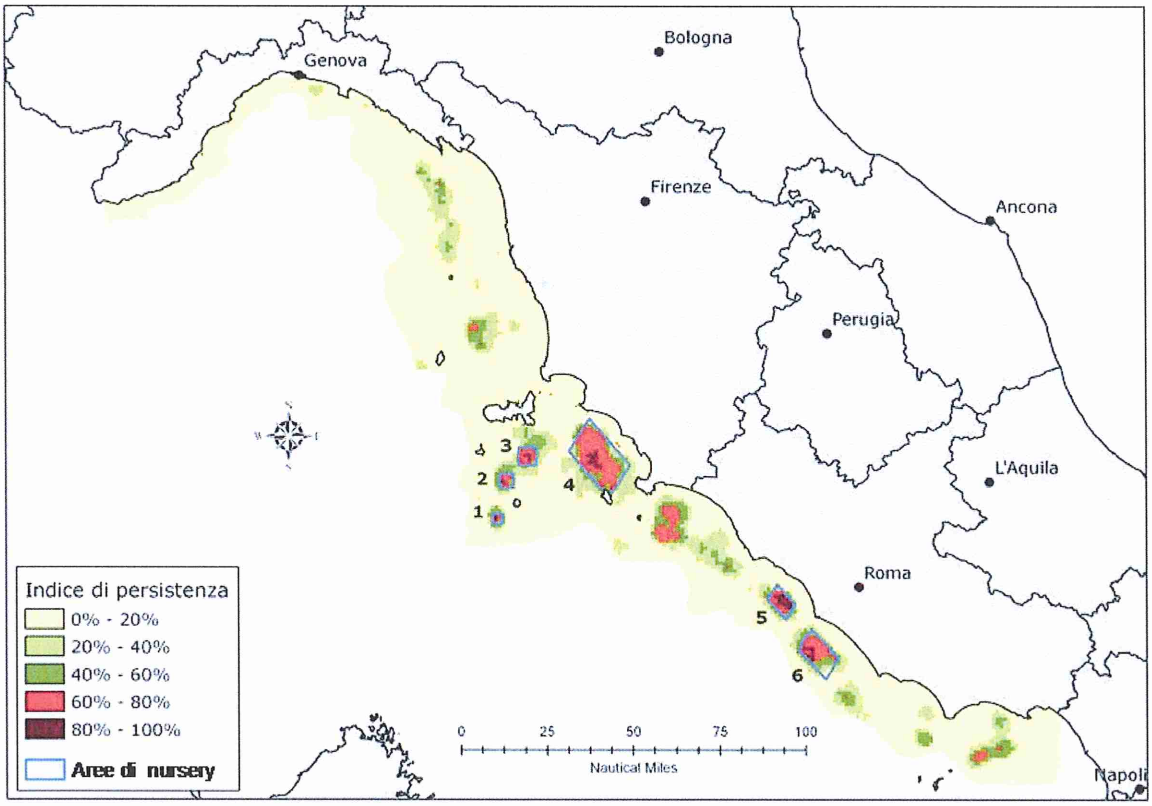


Fig. 5.34.1.1.1 Temporal persistence of *P. longirostris* nurseries in the GSA 09.

5.34.1.2. Growth

The growth of *P. longirostris* has been studied in the southern part of the GSA 09 (central Tyrrhenian Sea) using modal progression analysis (Ardizzone *et al*., 1990). The following sets of Von Bertalanffy growth parameters were estimated: Females: $L\infty = 43.5$, $K=0.74$, $t_0=-0.13$; Males: $L\infty = 33.1$, $K=0.93$, $t_0=-0.05$. The life cycle is of 3-4 years. Females grow faster than males attaining larger size-at-age.

P. longirostris diet is composed of a great variety of organisms; the prey items consisted mostly of external skeletons of bottom organisms, always crushed and often in an advanced state of deterioration. Crustaceans dominated the diet both qualitatively and quantitatively; they were characterized by a high abundance of peracarids, mainly represented by mysids (*Lophogaster typicus*) and amphipods (Lysianassidae). Molluscs (juvenile bivalves and gastropods), cephalopods (Sepiolids), small echinoderms, annelids, small fishes, foraminiferans, (Globigerinidae) and organic detritus are other important food item in the diet of the species (Mori *et al.*, 2000b).

5.34.1.3. Maturity

In the northern Tyrrhenian Sea, the reproduction area of *P. longirostris* is located from 150 to 350 m; mature females are present all year round, even though the species shows two peaks in reproductive activity, one in spring and another at the beginning of autumn (Mori *et al*., 2000a). In the central Tyrrhenian Sea, the southern part of GSA 09, a main winter spawning was hypothesized (Ardizzone *et al*., 1990). The size at onset of sexual maturity estimated for different years in northern Tyrrhenian Sea is about 24 mm CL (Mori *et al*., 2000a).

The number of oocytes in the ovary was related to the size of the females and ranged from 23,000 oocytes at 26 mm CL to 204,000 at 43 mm CL. An exponential relationship was observed between fecundity and carapace length: Fecundity = 0.0569 CL4.0177 (r = 0.829) (Mori *et al*., 2000a).

5.34.2. Fisheries

5.34.2.1. General description of fisheries

In the GSA 09 the deep water pink shrimp is one of the most important target species of the fishery carried out on the shelf break and upper part of continental slope. The species is exclusively exploited with otter bottom trawling.

The fishing grounds are located in the southern part of the GSA 09, to the south of Elba Island (northern and central Tyrrhenian Seas); they are mainly exploited by several trawlers of Porto Santo Stefano, Porto Ercole, Fiumicino, Terracina and Gaeta. *P. longirostris* belongs to a fishing assemblage distributed from 150 to 350 m depth, where the main target species are hake, *Merluccius merluccius*, horned octopus, *Eledone cirrhosa* and Norway lobster, *Nephrops norvegicus*, at greater depths (Biagi *et al.*, 2002; Colloca *et al*., 2003; Sartor *et al*., 2003; Sbrana *et al*., 2006).

The majority of bottom trawlers of GSA 09 operate daily fishing trips with some vessels (especially those of Porto Santo Stefano) staying out for two-three days and mainly in the summer. The mean number of fishing days/year per vessel carried out by the GSA 09 trawlers varied from 187 in 2004 to 177 in 2006. Due to the distance of the fishing grounds to the main harbours, fishing activity targeting *P. longirostris* shows some seasonal variations, with maxima from mid spring to mid autumn.

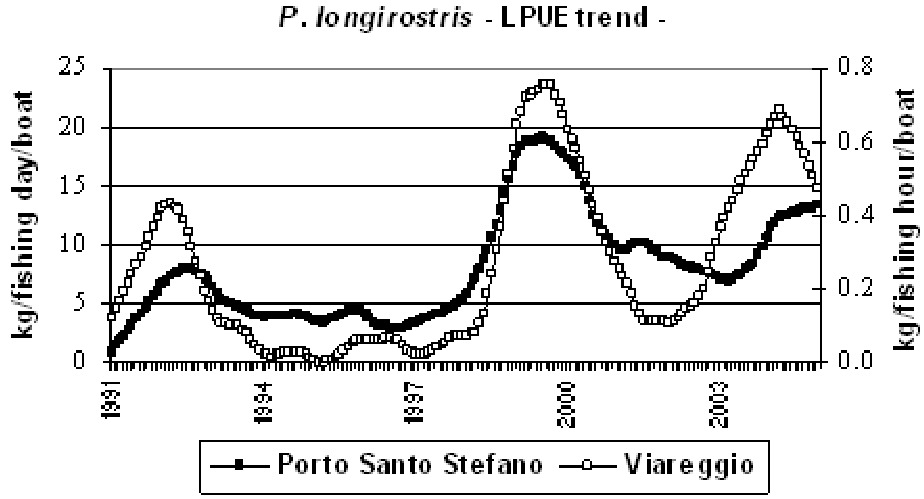


Fig. 5.34.2.1.1 *P. longirostris* LPUE of P. S. Stefano and Viareggio trawlers since 1991 (bottom).

The size structure of the landings, according to the DCR data, shows that the most exploited sizes ranged from 24 to35 mm CL (Fig. 5.34.2.1.2); the presence of specimens under the MLS (20 mm CL) is negligible. According to the growth pattern of the species, fishing exploits mainly 1^+ - 3^+ age classes.

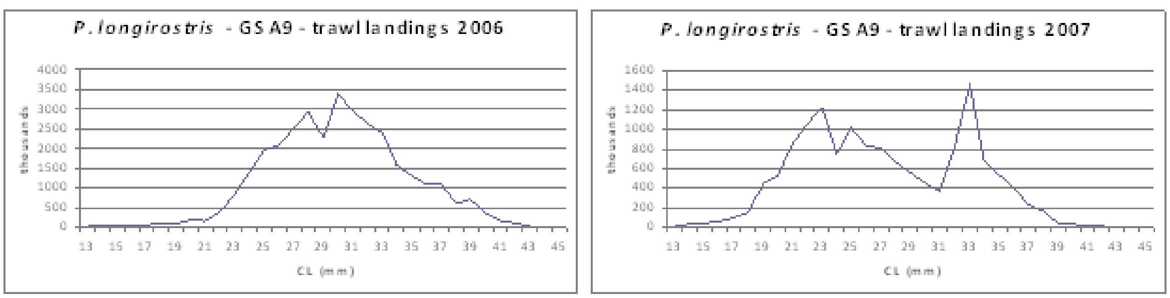


Fig. 5.34.2.1.2 Length frequency distribution of *P. longirostris* landed in the GSA 09 in 2006 and 2007.

5.34.2.2. Management regulations applicable in 2009 and 2010

The minimum legal landing size is 20 mm Carapace Length (EC regulation 1967/2006). The other management regulations are the same described for hake in the GSA 09.

5.34.2.3. Catches

5.34.2.3.1. Landings

Total landings of deep water rose shrimps fluctuated from 161 tons in 2002 to 254 tons in 2008, showing a peak in 2006 corresponding to 462 tons (Fig. 5.34.2.3.1.1; Tab. 5.34.2.3.1.1). The landings were mainly taken by demersal otter trawlers. The fluctuating trend is a proper characteristic of the landings of this species, as shown by the LPUE produced by the fleets of Porto Santo Stefano and Viareggio in the period 2001-2005 (Sartor *et al*., 2005) (Fig. 5.34.2.1.1). The values of the two fleets showed the same temporal pattern with maxima in 1992, 1999 and 2004. Landings from 2009 were not submitted by the Italian authorities.

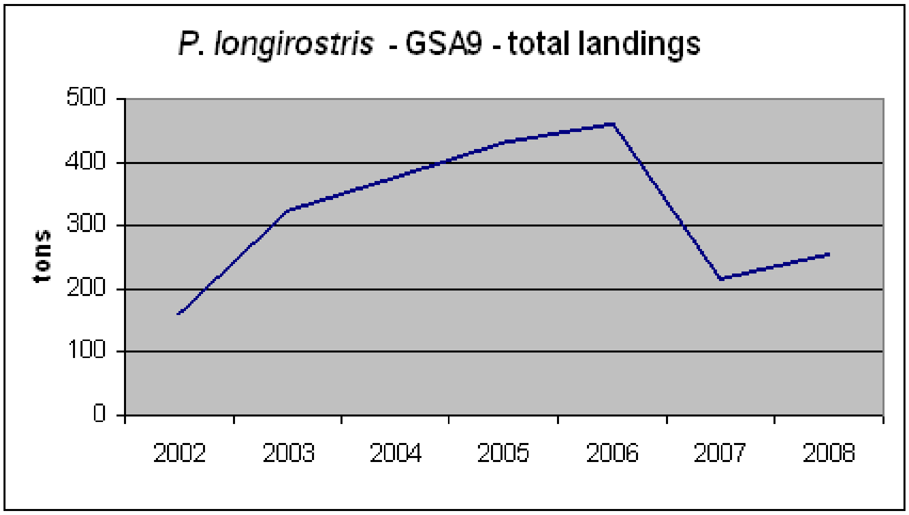


Fig. 5.34.2.3.1.1 Total landings in GSA 09.

Tab. 5.34.2.3.1.1 Annual landings (t) by fishing technique in GSA 09 as provided through the official DCF data call 2010.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	9	ITA						0					
DPS	9	ITA	GNS	DEMSP				4			2	1	
DPS	9	ITA	GTR	DEMSP				4	1				
DPS	9	ITA	OTB	DEMSP				155	42	55	90	187	
DPS	9	ITA	OTB	DWSP								0	
DPS	9	ITA	OTB	MDDWSP				212	388	407	125	66	
DPS	9	ITA	PS	SPF				0					
Sum								375	431	462	217	254	

5.34.2.3.2. *Discards*

Discards of *P. longirostris* are scarce; according to Sbrana *et al*. (2006) they ranged from 0.35 to 1.24% of the total catch of the species. Discards occurred mainly on the fishing grounds located at depths of less than 200 m, where juvenile specimens are more abundant.

About 9 t of discards were reported to SGMED-09-02 for 2006.

5.34.2.3.3. *Fishing effort*

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.34.2.3.3.1. After 2006, the effort of the major demersal trawler fleet decreased slightly.

Tab. 5.34.2.3.3.1 Trends in annual fishing effort (kW*days) by fishing technique deployed in GSA 09, 2004-2008. No data were provided for 2009 by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
9	ITA				VL0006					296		
9	ITA				VL0612		31025	45782	71302	4865	12129	
9	ITA	DRB	MOL		VL1218		18652	20370	13504	29808	28266	
9	ITA	GNS	DEMSP		VL0006				14365	9687	7681	
9	ITA	GNS	DEMSP		VL0612		204925	219978	146971	201390	146006	
9	ITA	GNS	DEMSP		VL1218		100498	59006	49194	62666	67944	
9	ITA	GNS	SLPF		VL0612		4857				3707	
9	ITA	GTR	DEMSP		VL0006				1417	4451		
9	ITA	GTR	DEMSP		VL0612		75571	121141	100767	142363	43116	
9	ITA	GTR	DEMSP		VL1218		3222	19168	11102	14510	6610	
9	ITA	LLD	LPF		VL0612		6569	17394	3581	5904	25890	
9	ITA	LLD	LPF		VL1218		1611	4427	24956	5535	12094	
9	ITA	LLS	DEMF		VL0612		37454	75215	18823	4330		
9	ITA	LLS	DEMF		VL1218		3914	9998				
9	ITA	LTL	LPF		VL0006				3198	687		
9	ITA	OTB	DEMSP		VL0612		7282	6524	15126	21176	14595	
9	ITA	OTB	DEMSP		VL1218		118419	113284	77407	171295	221969	
9	ITA	OTB	DEMSP		VL1824		515183		69690	200680	478813	
9	ITA	OTB	DEMSP		VL2440		125282					
9	ITA	OTB	MDDWSP		VL1218		151739	183842	177083	158561	57869	
9	ITA	OTB	MDDWSP		VL1824		85625	737780	692516	404814	75728	
9	ITA	PS	SPF		VL0612			10014				
9	ITA	PS	SPF		VL1218			3703				
9	ITA	PS	SPF		VL1824		6526	6055				
9	ITA	SB-SV	DEMSP		VL0006				3780	3664	4506	
9	ITA	SB-SV	DEMSP		VL0612		127810	191056	133213	74903	62000	
9	ITA	SB-SV	DEMSP		VL1218		22438	10582	13566	2988	5196	

5.34.3. Scientific surveys

5.34.3.1. MEDITS

5.34.3.1.1. Methods

From 1994 two trawl surveys are regularly carried out each year: MEDITS, in spring, and GRUND, in autumn. The two surveys gave a similar temporal increasing trend in density and biomass of deep water pink shrimp, even though large fluctuations are present from year to year (Fig. 5.34.3.1.1.1). A similar increasing trend in abundance has been observed also in other Italian geographic subareas and could be related to the warming trend in water temperature. *P. longirostris* is a thermophile species that could benefit by the ongoing climatic change in the Mediterranean region. The relationship between environmental variability and deep-sea pink shrimp population dynamic has not been investigated yet.

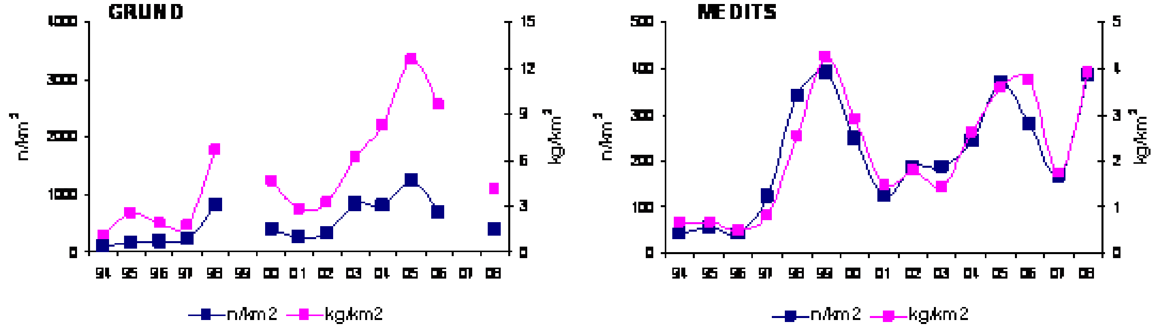


Fig. 5.34.3.1.1.1 *P. longirostris*: GRUND and MEDITS trends in density and biomass from 1994 to 2008 in GSA 09.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 09 the following number of hauls was reported per depth stratum (s. Tab. 5.34.3.1.1.1).

Tab. 5.34.3.1.1.1. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA09_010-050	19	18	18	18	19	18	18	18	13	13	13	14	13	13	13	14
GSA09_050-100	19	20	18	19	18	19	20	20	15	15	15	14	16	16	13	14
GSA09_100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	28	27
GSA09_200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	30	28
GSA09_500-800	31	30	31	28	30	28	27	29	24	22	21	20	20	17	18	20

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.34.3.1.2. Geographical distribution patterns

The stock is more abundant in the southern part of the GSA (Tyrrhenian Sea) as showed in Figure 5.34.3.1.2.1.

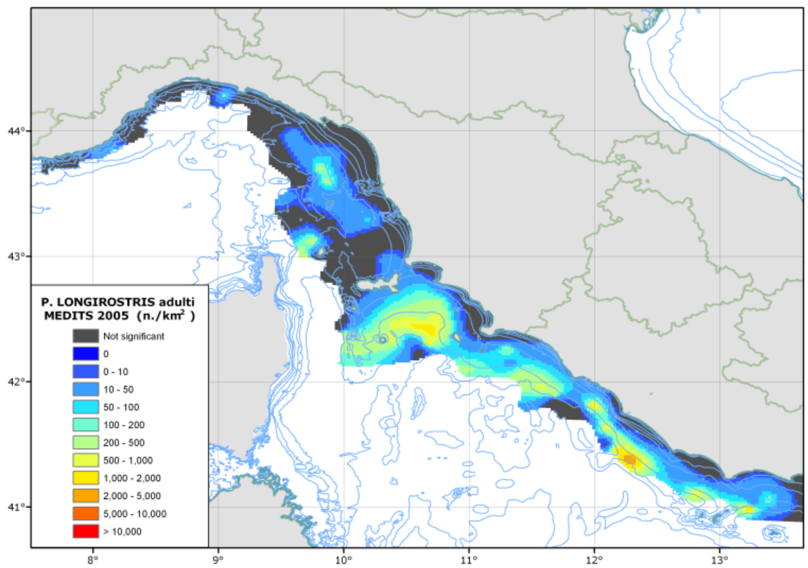
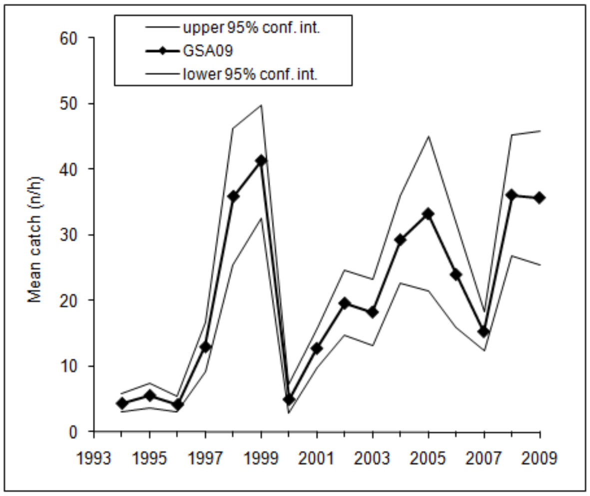


Fig. 5.34.3.1.2.1 *P. longirostris*: GRUND and MEDITS trends in density and biomass from 1994 to 2008 in GSA 09.

5.34.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the pink shrimp in GSA 09 was derived from the international survey MEDITS. Figure 5.34.3.1.3.1 displays the estimated trend in pink shrimp abundance and biomass in GSA 09.

The estimated abundance and biomass indices do not reveal a clear trend but appear to be above average recently.



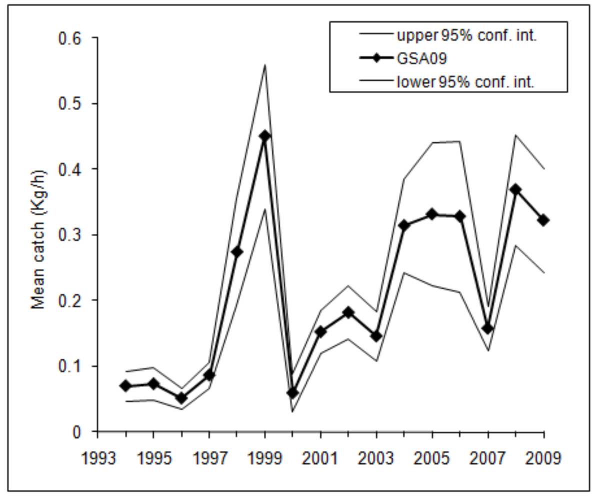


Fig. 5.34.3.1.3.1 Abundance and biomass indices of pink shrimp in GSA 09.

5.34.3.1.4. Trends in abundance by length or age

The following Fig. 5.34.3.1.4.1 and 2 display the stratified abundance indices of GSA 09 in 1994-2001 and 2002-2009.

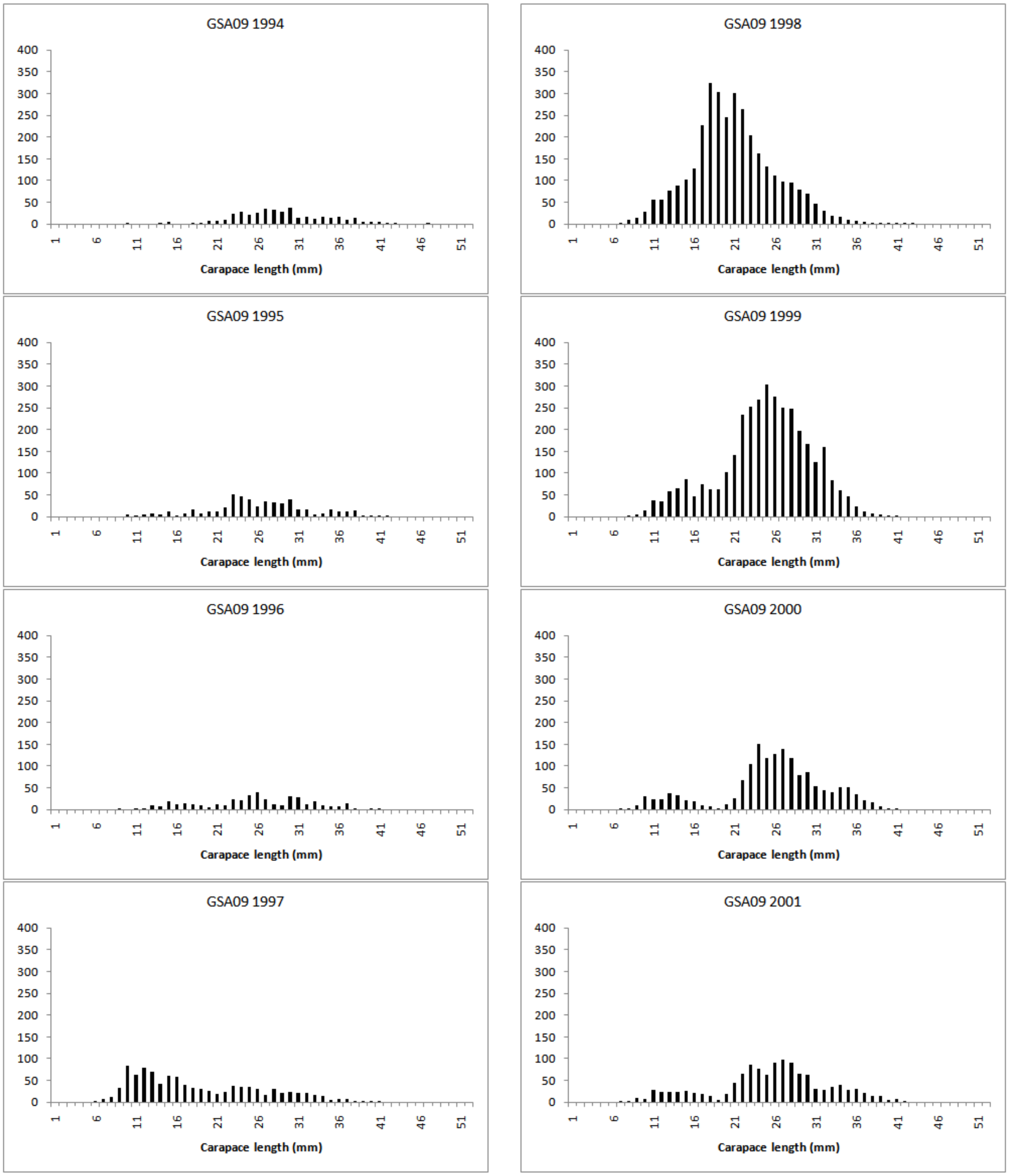


Fig. 5.34.3.1.4.1 Stratified abundance indices by size, 1994-2001.

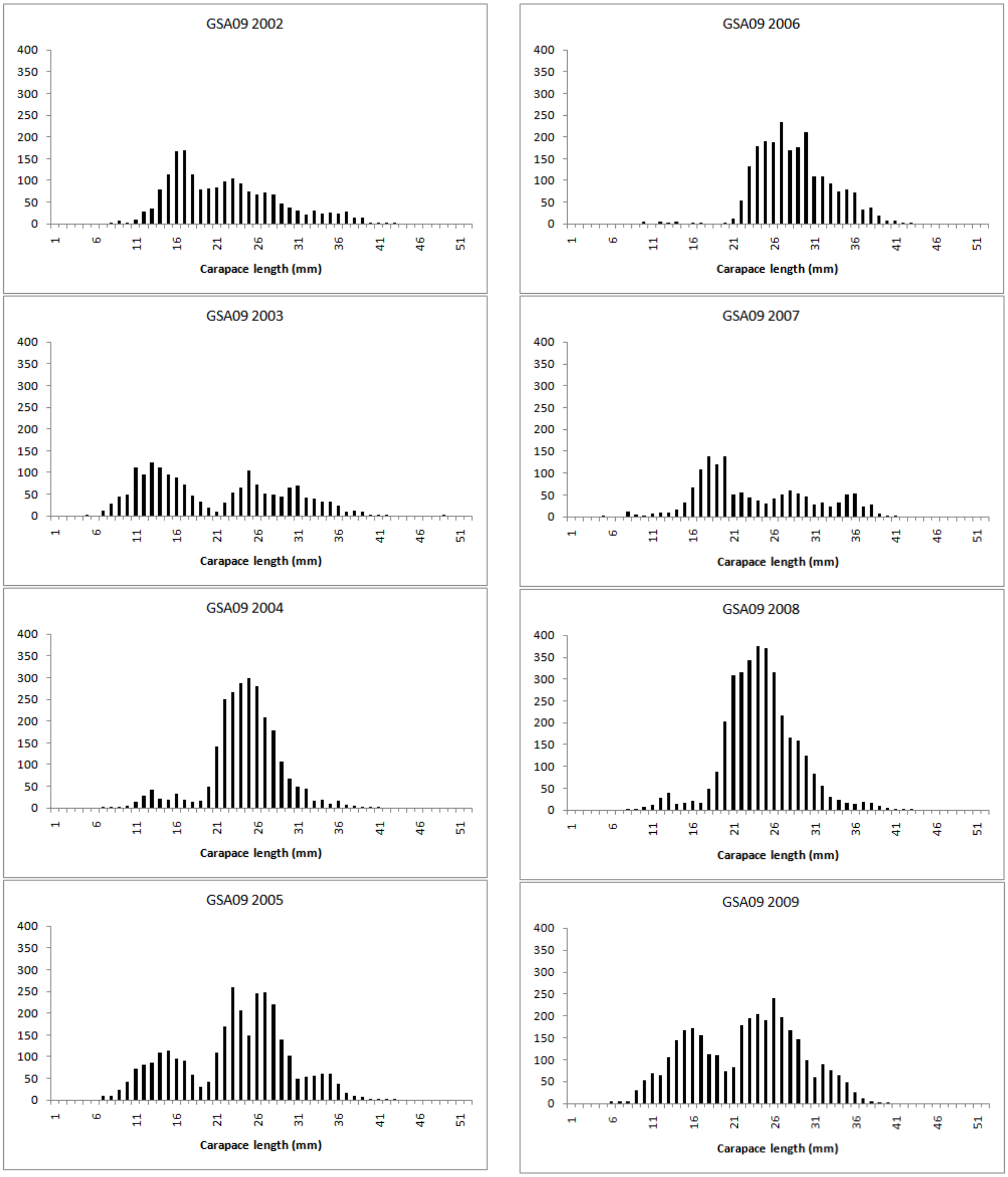


Fig. 5.34.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.34.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.34.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.34.4. Assessment of historic stock parameters

5.34.4.1. Method 1: SURBA

5.34.4.1.1. Justification

The MEDITS survey provided the longer standardized time-series data on abundance and population structure of *P. longirostris* in the GSA 09.

5.34.4.1.2. Input parameters

The survey-based stock assessment model SURBA (Needle, 2003) was used to reconstruct trend in population structure and fishing mortality.

The following set of input data and parameters were used (Tab. 5.34.4.1.2.1 and 2).

Tab. 5.34.4.1.2.1 Input data used in the SURBA model.

MEDITS					GRUND			
Mean abundance								
	Age				Age			
Year	0	1	2	3+	0	1	2	3+
1994		26.0	9.7	3.0	35.3	14.6	4.7	0.8
1995		33.8	7.1	2.5	80.6	23.6	4.4	0.4
1996		22.6	7.1	1.6	93.8	16.2	3.0	0.4
1997		33.2	7.8	1.0	74.2	18.2	2.0	0.1
1998		132.8	9.4	0.9	444.4	33.2	2.6	0.2
1999		253.7	45.7	1.9	339.5	53.1	5.6	0.2
2000		155.6	39.6	3.7	234.7	73.0	8.6	0.2
2001		73.2	18.8	3.9	141.9	40.7	6.7	0.3
2002		70.1	17.4	4.0	176.3	28.1	3.9	0.6
2003		58.1	17.3	2.5	235.8	63.8	6.3	0.7
2004		186.9	16.5	1.4	509.8	93.4	23.4	26.8
2005		216.3	29.7	2.4	567.0	177.4	16.9	1.0
2006		209.5	53.6	7.7	470.9	187.0	14.6	1.2
2007		57.9	26.0	4.0	363.2	101.6	8.2	0.6
2008		260.7	16.4	3.7				
2009		278.7	64.5	3.6				
Proportion mature								
	Age							
Year	0	1	2	3+	0	1	2	3+
1994		0.8	1	1	0.4	0.8	1	1
1995		0.8	1	1	0.4	0.8	1	1
1996		0.8	1	1	0.4	0.8	1	1
1997		0.8	1	1	0.4	0.8	1	1
1998		0.8	1	1	0.4	0.8	1	1
1999		0.8	1	1	0.4	0.8	1	1
2000		0.8	1	1	0.4	0.8	1	1
2001		0.8	1	1	0.4	0.8	1	1
2002		0.8	1	1	0.4	0.8	1	1
2003		0.8	1	1	0.4	0.8	1	1
2004		0.8	1	1	0.4	0.8	1	1
2005		0.8	1	1	0.4	0.8	1	1
2006		0.8	1	1	0.4	0.8	1	1
2007		0.8	1	1	0.4	0.8	1	1
2008		0.8	1	1				
2009		0.8	1	1				
Mean weights								
	Age							
Year	0	1	2	3+	0	1	2	3+
1994		15.5	18.1	25.1	4.5	16.5	18.1	25.0
1995		15.1	18.0	24.7	5.0	13.8	17.4	24.6
1996		16.5	18.1	25.0	3.9	15.8	17.1	24.9
1997		13.8	17.4	24.6	5.2	15.9	17.2	24.0
1998		15.8	17.1	24.9	4.9	14.7	18.0	23.8
1999		15.9	17.2	24.0	5.0	14.7	18.2	24.6
2000		14.7	18.0	23.8	4.5	16.0	18.0	24.2
2001		14.7	18.2	24.6	5.2	14.9	17.6	24.3
2002		16.0	18.0	24.2	5.1	14.7	17.1	23.8
2003		14.9	17.6	24.3	5.0	14.9	18.0	24.7
2004		14.7	17.1	23.8	4.3	16.5	17.8	24.4
2005		14.9	18.0	24.7	4.7	5.0	17.2	18.5
2006		16.5	17.8	24.4	5.1	17.2	18.5	23.8
2007		17.2	18.5	23.8	4.9	17.2	18.5	23.8
2008		17.2	18.5	23.8				
2009		16.5	17.8	24.4				

Tab. 5.34.4.1.2.2 Input parameters used in the SURBA model.

• **Growth**
L∞ = 43.5 mm carapace length
K = 0.6
to = 0
• **Length-Weight relationhips**
a = 0.00686
b = 2.24
• **Natural mortality**
M = 1..0 (age 0), 0.78 (age 1), 0.69 (age 2), 0.65 (age 3) (ProdBiom)
• **Length-at-maturity (L50)**
L50 = 24 mm
Lc100 = 20 mm

Standardized time series of MEDITS length-frequency-distributions were sliced into different age-groups using the same growth parameters for the whole time series (Fig. 5.34.4.1.2.1). The resulting age structures showed a very high internal consistency, thus showing the reliability of the growth parameters used (Fig. 5.34.4.1.2.1).

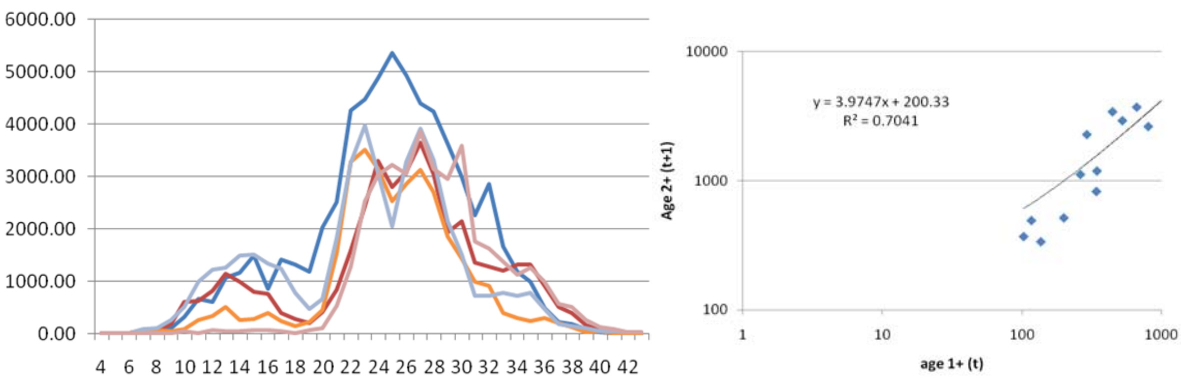


Fig. 5.34.4.1.2.1 Length frequency distributions of *P. longirostris* for 2000 to 2005 (left). Relationship between the estimated shrimp abundance at age 1 (time t) and age 2 (time t+1) (right).

A preliminary attempt to use SURBA was made excluding 0+ (CL < 20mm) specimens from the dataset due to their low catchability with the MEDITS trawl net. A fixed M mortality value (M=1.0) obtained from literature was used.

5.34.4.1.3. Results

Fitted year effect shows strong fluctuations from year to year with a decrease since 2006, while the age effect shows a flat-topped selection pattern for stock mortality with an increase from age 3 to age 6. Fitted cohort effects (Figure 5.34.4.1.3.1) are high in recent years.

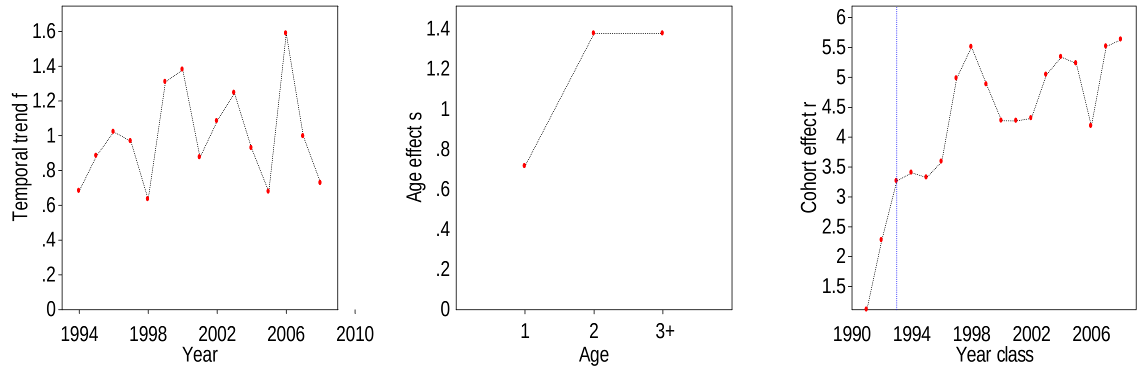


Fig. 5.34.4.1.3.1 MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.

Average mortality (F_{1-3}) estimated from MEDITS ranged between 0.63 and 1.8 (0.76 in 2008). GRUND gives higher F_{1-3} values with some outliers in 2002-03. Relative indices derived from MEDITS survey for the period 1994-2008 indicated an increasing trend of the spawning stock biomass with highest values in 1999, 2006 and 2008. In 2008 the SSB was the highest observed since 1994. GRUND data showed a very similar temporal trend in SSB (Fig. 5.34.4.1.3.2). Young of the year (0+) are poorly sampled by the MEDITS survey. GRUND survey showed a clear increase of 0+ specimens since 1994 (Fig. 5.34.4.1.3.2).

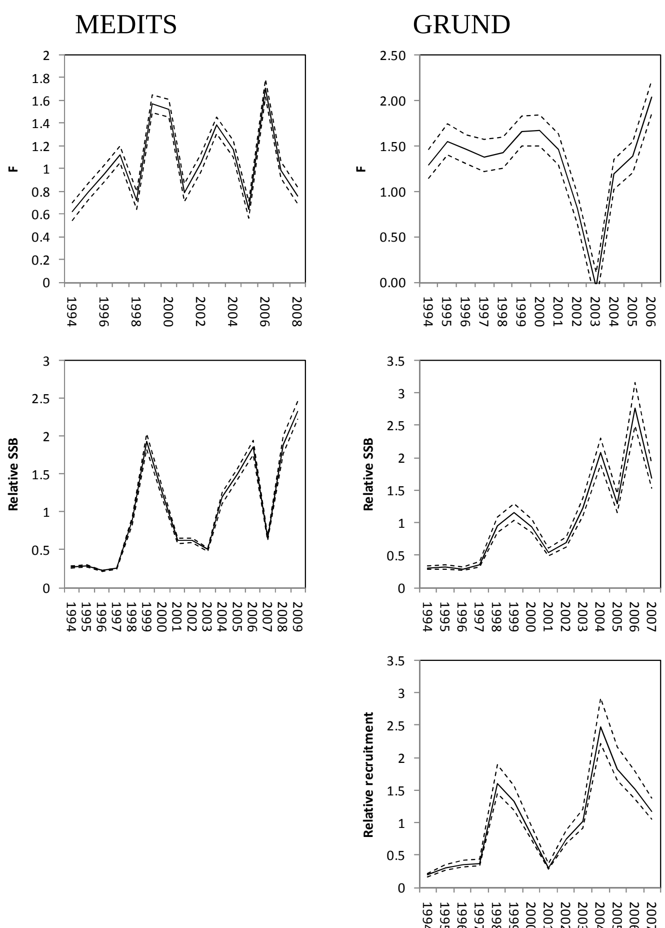


Fig. 5.34.4.1.3.2 Estimated trend in F_{1-3}, relative SSB and recruitment index at age 1+ of *P. longirostris* in the GSA 09, dotted lines are 2.5% and 97.5% confidence intervals.

Model diagnostics

The SURBA model for *P. longirostris* fits very well on survey data as showed in Fig. 5.34.4.1.3.3.

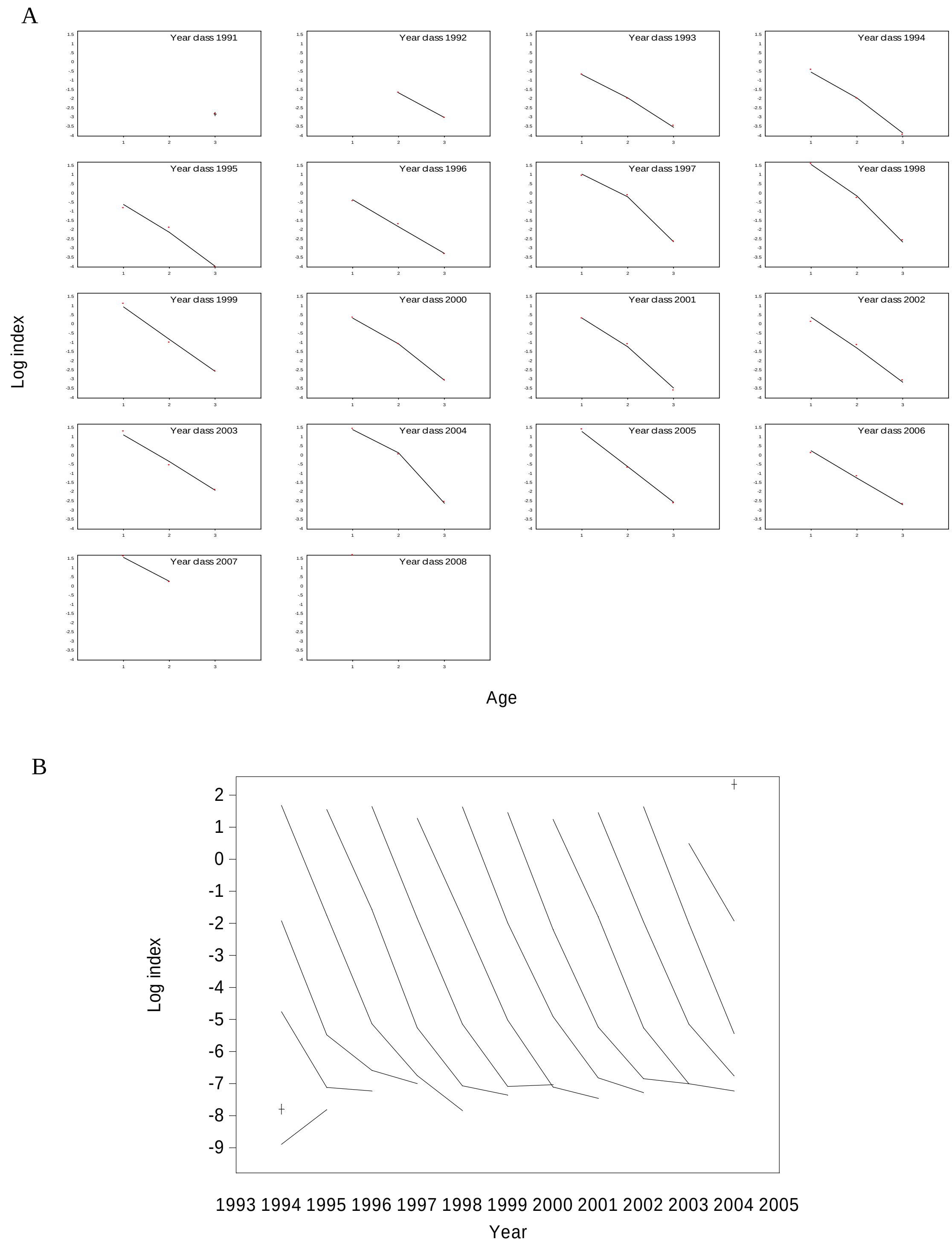


Fig. 5.34.4.1.3.3. Model diagnostic for SURBA model of in the GSA 9. A) Comparison between observed (points) and fitted (lines) MEDITS survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.

5.34.4.2. Method 2: LCA

5.34.4.2.1. Justification

The pseudo-cohort analysis VIT was applied using data from 2006 to 2008. Landings from 2009 were not submitted by the Italian authorities, Thus, SGMED was not able to update the VIT analysis.

5.34.4.2.2. Input parameters

Data coming from DCR provided at SGMED-09-02 contained information on deep water pink shrimp landings and the respective size structure for 2006-2007 (Fig. 5.34.4.2.2.1). VIT software was used to run an LCA analysis for each year separately, using data in Tab. 5.34.4.2.2.1 and biological parameters listed in Tab. 5.34.4.1.2.2. The same M-vector used for SURBA (ProdBiom estimation) was used (age 1: 1; age 2: 0.78; age 3: 0.69; age 4: 0.65; age 5. 0.5).

Tab. 5.34.4.2.2.1. Input data for LCA of deep water pink shrimp in GSA 09.

	Landings (thousands)		
CL (mm)	2006	2007	2008
13	18.2	11.1	
14	27.2	32.1	
15	65.9	40.2	
16	55.8	52.0	
17	67.4	102.0	419.9
18	120.8	147.0	584.2
19	91.6	447.4	626.3
20	181.9	520.8	585.6
21	164.5	843.7	650.6
22	396.3	1059.5	771.0
23	850.9	1223.9	703.7
24	1409.8	746.0	742.4
25	1938.5	1017.4	687.0
26	2088.3	827.1	532.3
27	2509.0	804.4	628.9
28	2907.6	667.7	718.3
29	2257.0	557.5	633.8
30	3385.7	446.6	593.5
31	2949.6	374.8	638.4
32	2627.6	832.4	696.6
33	2373.1	1460.4	550.4
34	1579.8	678.1	446.6
35	1298.3	531.9	361.0
36	1074.2	397.6	333.4
37	1072.9	232.8	214.0
38	596.3	165.8	212.4
39	690.0	46.7	139.7
40	363.0	29.1	95.6
41	170.7	12.6	36.8
42	109.9	6.6	24.5
43	16.1	3.7	61.0

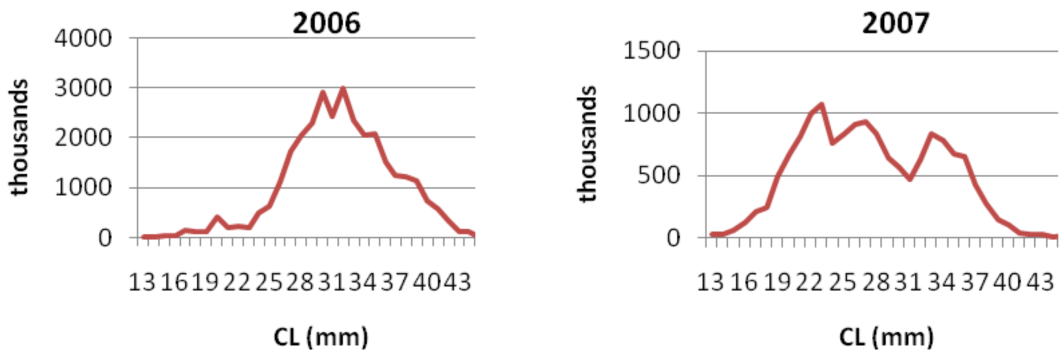


Fig. 5.34.4.2.2.1. Length frequency distributions of the *P. longirostris* catch in 2006 and 2007 in GSA 09.

5.34.4.2.3. Results

Deep water pink shrimp landings in 2006 and 2008 were concentrated on adults of age classes 2-4. High landings were observed in 2006. Fishing mortality peaked for specimens of age classes 2 and 3 (Fig. 5.34.4.2.3.1). F_{1-3} (obtained averaging the estimated F values of age classes 2, 3 and 4) was 0.53, 0.61 and 0.58 in 2006, 2007 and 2008, respectively.

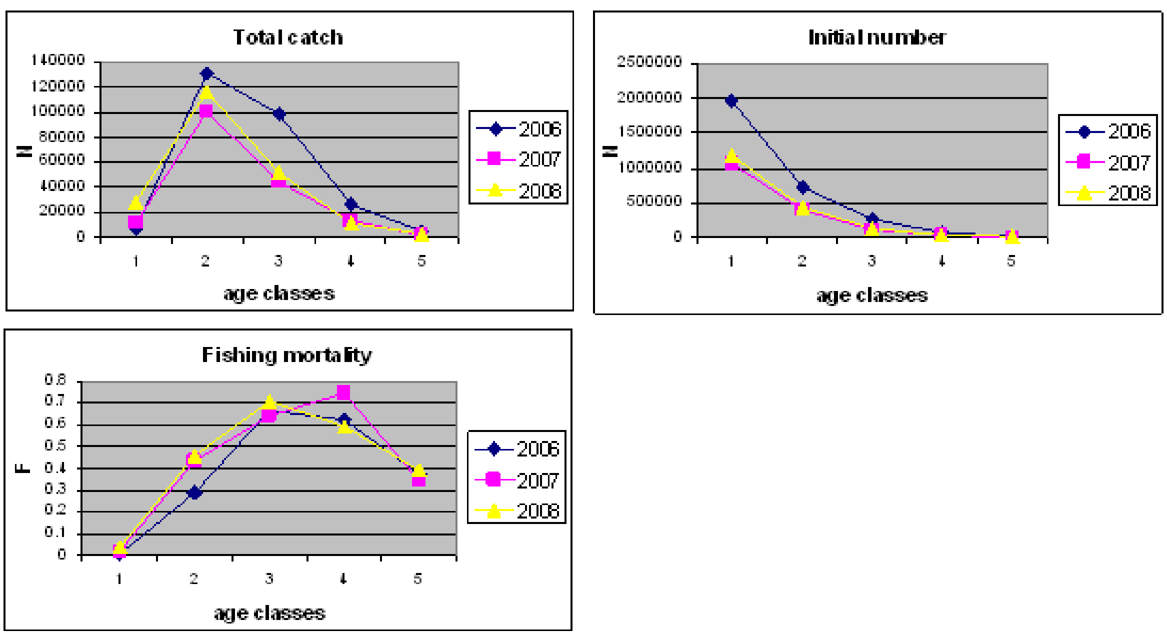


Fig. 5.34.4.2.3.1 LCA outputs: catch numbers, numbers-at-age and fishing mortality at age of *P. longirostris* in the GSA 09.

5.34.5. Long term prediction

5.34.5.1. Justification

The Yield software (Hoggarth *et al*., 2006) was used to estimate $F_{0.1}$ as target equilibrium YPR reference point for the stock assuming a 20% uncertainty in parameters estimations.

5.34.5.2. Input parameters

The following parameters were used to estimate $F_{0.1}$ through Yield software.

Tab. 5.34.5.2.1 Input to long term forecast.

L∞ = 43.5 mm carapace length
K = 0.6
t_0 = 0
a = 0.00686
b = 2.24
M = 1.2 CV=0.1
L_{50} = 24 mm, CV=0.05
Lc100 = 20 mm, CV=0.05
Spawning season: March-August
Fishing season: January-December

5.34.5.3. Results

Fig. 5.34.5.3.1 shows the probability distribution of $F_{0.1}$ (1,000 simulations). Uncertainty in model parameters produced considerable variations in $F_{0.1}$ which ranged between 0.5 and 1.1 (mean = 0.7) with an increased probability for values between 0.7 and 0.8.

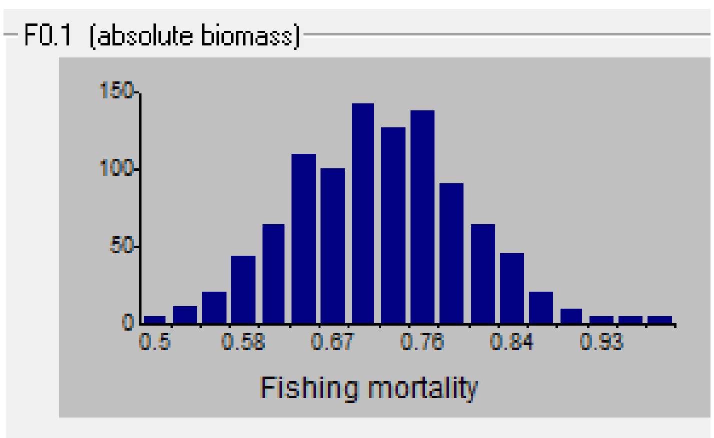


Fig. 5.34.5.3.1 Probability distribution of $F_{0.1}$ obtained using the Yield software.

According to these $F_{0.1}$ estimates, Fcurr was in most of the year above the average and maximum estimated $F_{0.1}$ values.

5.34.6. Data quality

Medits survey data were available from 1994. A check of hauls allocation between GSA 9 and 10 needs to be done before calculation of indices from JRC MEDITS database. Landings from 2009 were not submitted by the Italian authorities and thus SGMED was not able update the VIT analysis. Effort data appear not consistent with previous estimates for the GSA. Due to lack of numbers-at-age or numbers-at-length from the landings the update of the assessment in 2009 was therefore not carried out.

5.34.7. Scientific advice

5.34.7.1. Short term considerations

5.34.7.1.1. State of the spawning stock size

SSB showed an increasing trend during the last 13 years with the highest value in the last year.

5.34.7.1.2. State of recruitment

Relative indices for age 1+ from survey data indicated a general increasing trend since 1994 with three main recruitment peaks in 1999, 2005 and 2009. In 2007 recruitment estimated by GRUND survey (age 0) was 61% of the short term average (2004-06). In 2009 recruitment at age 1 (MEDITS) was 180% of the short term average (2005-07). VIT estimates for 2006-2008 showed a reduced recruitment in 2007.

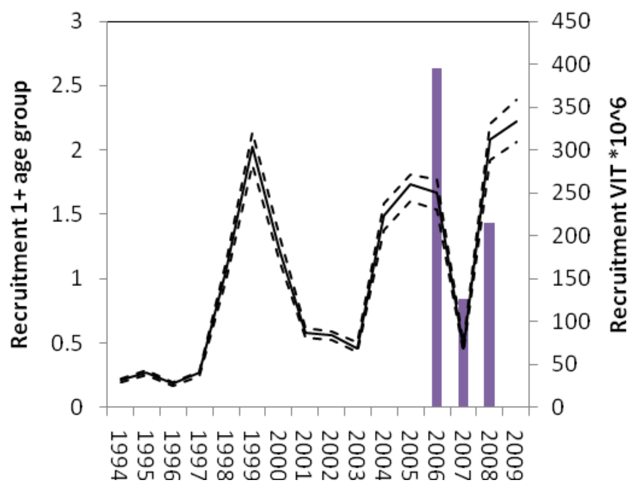


Fig. 5.34.7.1.2.1 Estimated trend in relative recruitment of *P. longirostris* in the GSA 09. Lines are SURBA indices at age 1+, dotted lines are 2.5% and 97.5% confidence intervals. Bars are annual VIT recruitments estimates.

5.34.7.1.3. State of exploitation

SGMED proposes $F_{0.1}$=0.7 as limit management reference point consistent with high long term yields.

According to the F estimates obtained using trawl surveys indices (GRUND and MEDITS) with SURBA, F_{curr} was in most of the years above the average and maximum estimated $F_{0.1}$ values. In this case, the stock would not appear to be able to sustain the current level of fishing effort in the GSA 09 and thus the stock is considered overexploited using survey data estimates.

A different picture comes from the F estimates through LCA on the last three years of landing data. $F_{1\text{-}3}$ was between 0.5 and 0.6 for the period 2006-2008, little below the estimated reference value of $F_{0.1}$=0.7.

SGMED advice relies on the LCA and considers the stock has been harvested sustainably consistent with high long term yields in 2006-2008. It is important to consider that this stock could be strongly driven by environmental and ecological factors (e.g. water temperature, predatory release effect) that can make difficult to evaluate the effect of fishing on the stock.

5.35. Stock assessment of pink shrimp in GSA 10

5.35.1. Stock identification and biological features

5.35.1.1. Stock Identification

The stock of pink shrimp was assumed in the boundaries of the whole GSA10, lacking specific information on the stock identification. The pink shrimp is an epibenthic species and inhabits the muddy or sandy-muddy bottoms of the continental shelf. A gradient of size increasing with depth has been observed in GSA 10 as in other areas, being the smallest specimens fished more frequently in the upper part of the continental shelf (100-200 m), while the largest ones are mainly distributed along the slope at depths greater than 200 m (Spedicato *et al*., 1996). Aggregations with higher abundance were localised between 100 and 200 m depth, with some intrusions in the deeper waters in three sub-areas. Two most important patches were located in the Gulf of Naples and along the Calabrian coasts in correspondence with Cape Bonifati, while a third one in the Gulf of Salerno (Lembo *et al*., 1999). These are the areas where also the main nurseries are localised (Lembo *et al*., 2000a).

In the Central-Southern Tyrrhenian Sea the occurrence of mature females was observed in spring (May), summer (July-August) and autumn (October), with a higher relative frequency in spring-summer seasons (Spedicato et al., 1996). Thus, a continuous recruitment pattern is shown which, however, exhibits a main pulse in the autumn season. At 16 mm carapace length the pink shrimp is considered recruited to the grounds (SAMED, 2002)

The overall sex ratio is about 0.5. The structure of the sizes of *P. longirostris* is characterised by differences in growth between the sexes, the larger individuals being females. The pink shrimp is a short-living crustaceans with a life span of about 4 years (Carbonara *et al*., 1998).

The deep-water rose shrimp with hake and red mullet is a key species of fishing assemblages in the central-southern Tyrrhenian Sea. In the last decade it is generally also ranked among the species with higher abundance indices (number of individuals) in the trawl surveys (e.g. Spedicato *et al*. 2003) as observed for different Mediterranean areas (Abellò *et al*., 2002).

The pink shrimp is caught on the same fishing grounds as European hake and the production of this shrimp is steadily growing in the last decade in the southern basin and it reached in 2006 about 10% of the demersal landings.

5.35.1.2. Growth

Past estimates of the growth pattern of the pink shrimp females were obtained using different methods based on the LFD analysis (modal progression analysis-MPA, Elefan, Multifan) applied to Grund data from 1990 to 1995. Parameters of VBGF were as follows: L_∞=45.9; K=0.673 t_0= -0.251 (Carbonara et al., 1998). VBGF parameters were also re-estimated during the Samed project (SAMED, 2002) using the Medits time series from 1994 to 1999, that gave the following values: females: CL_∞=45.0 mm, K=0.7, t_0= -0.15; males: CL_∞=40.0 mm; K=0.78; t_0= -0.2. Maximum carapace lengths (CL) observed for females and males were respectively 42.3 mm and 39 mm. The growth parameters from DCF (2006-2008) are as follows: females CL_∞=46 mm, K=0.575, t_0= -0.2; males CL_∞=40 mm, K=0.68, t_0= -0.25. They also describe a fast growing pattern albeit slightly lower than that previously observed. The length weight relationships by sex and for sex combined are as follows: females: a=0.935, b=2.452; males a=0.974; b=2.335 sex combined a=0.920; b= 2.445.

5.35.1.3. Maturity

The maturity ogive Fig. 5.35.1.3.1 was obtained from a maximum likelihood procedure applied grouping as mature individuals belonging to the maturity stage 2b-2e (according to the Medits maturity scale). The fitting of the curve was fairly good, however the estimates of the size at first maturity $L_{m50\%}$ (18.7 cm ±0.06 cm) and of the maturity range (0.31 cm ±0.009 cm), reported in the figure below, seem underestimated if compared with literature values (average of the smallest females 24 mm CL; in Relini et al., 1999).

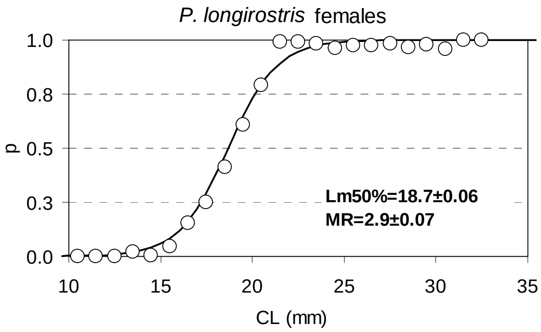


Fig. 5.35.1.3.1 Maturity ogive of pink shrimp in the GSA10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio from DCF (2006-2008 data) evidenced the prevalence of males between 1.4 and 2.0 cm, while from 2.4 cm onwards the proportion of females was dominant (Fig. 5.35.1.3.2).

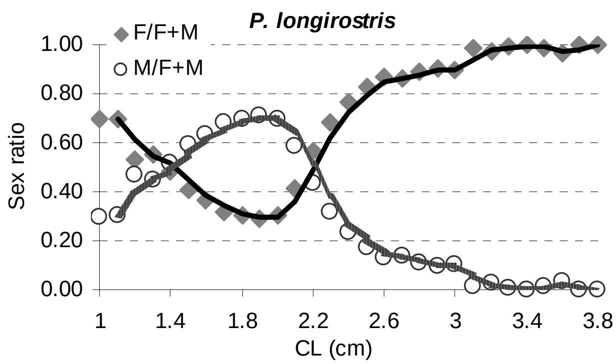


Fig. 5.35.1.3.2 Sex ratio over lenght of pink shrimp in the GSA10.

5.35.2. Fisheries

5.35.2.1. General description of fisheries

The pink shrimp is only targeted by trawlers and fishing grounds are located offshore 50 m depth, on the continental shelf and slope of the whole GSA. The pink shrimp occurs mainly with *M. merluccius*, *M. barbatus*, *Eledone cirrhosa*, *Illex coindetii* and *Todaropsis eblanae, N. norvegicus*, *P. blennoides*, depending on depth and area.

5.35.2.2. Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures as closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties. After 2000, in agreement with the European Common Fisheries Policy, a gradual decreasing of the fleet capacity is implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990. Two closed areas were also established in 2004 along the mainland, in front of Sorrento peninsula

(Napoli Gulf) and Amantea (Calabrian coasts), although these protected area mainly cover the distribution of coastal species. Other measures on which the management regulations are based are technical measures (mesh size) and minimum landing sizes (EC 1967/06). In the GSA 10 the fishing ban has not been mandatory in the past, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it has been mandatory. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

5.35.2.3. Catches

5.35.2.3.1. Landings

Available landing data are from DCF regulations. SGMED-10-02 received Italian landings data for GSA 10 by fishing gears which are listed in Tab. 5.35.2.3.1.1. Almost all landings are from trawlers. No data were provided for 2009 by the Italian authorities.

Tab. 5.35.2.3.1.1. Annual landings (t) by gear type, 2004-2008.

Somma di LW			FT_LVL4									
SPECIES	AREA	YEAR	"	GND	GNS	GTR	LLD	LLS	OTB	PS	SB-SV	Totale complessivo
DPS	10	2004	0.206		2.87	2.539		0.624	544.24	1.261	0.158	551.894
		2005	0.017	0.047	5.876	0.416	0.574	26.078	742.74			775.75
		2006							1087.7	1.042		1088.785
		2007							534.29			534.289
		2008			0.126				400.21			400.333

The catches of the species raised from 2004 to 2006 when 1089 tons were recorded and then declined to 400 tons in 2008.

5.35.2.3.2. Discards

1 t of discards in 2006 was reported to SGMED-10-02 through the DCR data call.

5.35.2.3.3. Fishing effort

Trend in fishing effort (kW*days) for GSA 10 by gear type, for 2004 to 2008 as reported through the DCF official data call is reported in Tab. 5.35.2.3.3.1.

Tab. 5.35.2.3.3.1 Trend in fishing effort (kW*days) for GSA10 by major gear types, 2004-2008. Data submitted through the DCF data call in 2010.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
10	ITA				VL0006				1347			
10	ITA				VL0612		84318	65385	32480	27509	24608	
10	ITA				VL1218		13612	27229	5986	18865	7513	
10	ITA	DRB	MOL		VL1218		10149	14848	23073	34394	21067	
10	ITA	FPO	DEMSP		VL0006				5938			
10	ITA	FPO	DEMSP		VL0612			14239				
10	ITA	GND	SPF		VL0006					1521	1437	
10	ITA	GND	SPF		VL0612			4316	8070		15882	
10	ITA	GND	SPF		VL1218		1895	3429			8303	
10	ITA	GNS	DEMSP		VL0006				221	9122	6623	
10	ITA	GNS	DEMSP		VL0612		45875	229661	74360	139622	124448	
10	ITA	GNS	DEMSP		VL1218						18180	
10	ITA	GTR	DEMSP		VL0006				30332	16894	13248	
10	ITA	GTR	DEMSP		VL0612		86781	82711	191382	140832	172542	
10	ITA	GTR	DEMSP		VL1218		12514	21108	28430	16110	17755	
10	ITA	LHP-LHM	CEP		VL0006				2369	3463	1018	
10	ITA	LHP-LHM	CEP		VL0612		1239	2450	4458	15003		
10	ITA	LHP-LHM	FINF		VL1218		716	1013				
10	ITA	LLD	LPF		VL0006						1968	
10	ITA	LLD	LPF		VL0612						2138	
10	ITA	LLD	LPF		VL1218		4627		10673	10266	14174	
10	ITA	LLS	DEMF		VL0006				11628	3467	2996	
10	ITA	LLS	DEMF		VL0612		104125	101629	61456	56957	26693	
10	ITA	LLS	DEMF		VL1218		13376	27517	61348	52670	32330	
10	ITA	OTB	DEMSP		VL0612		16454					
10	ITA	OTB	DEMSP		VL1218		44743		102448	127832	98014	
10	ITA	OTB	DEMSP		VL1824		90104		224283	204068	242063	
10	ITA	OTB	DWSP		VL1824						2388	
10	ITA	OTB	MDDWSP		VL1218		130612	247796	142430	169560	83026	
10	ITA	OTB	MDDWSP		VL1824		97221	239878	71963	86844	55526	
10	ITA	PS	LPF		VL0612					5291		
10	ITA	PS	LPF		VL1218					4926		
10	ITA	PS	SPF		VL0006				7337			
10	ITA	PS	SPF		VL0612		4653	27986				
10	ITA	PS	SPF		VL1218		49995	54113	68805	73452	20179	
10	ITA	SB-SV	DEMSP		VL0006				0			
10	ITA	SB-SV	DEMSP		VL0612		12786					
10	ITA	SB-SV	DEMSP		VL1218						8756	

5.35.3. Scientific surveys

5.35.3.1. Medits

5.35.3.1.1. Methods

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometre, using the swept area method.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls was reported per depth stratum (Tab. 5.35.3.1.1.1).

Tab. 5.35.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	9	10	10	10	10	10	10	10	9	9	9	9	9	9	9	9
GSA10_050-100	12	12	12	12	12	12	12	12	10	10	10	10	10	10	10	10
GSA10_100-200	20	20	20	20	20	20	20	20	17	17	17	17	17	17	17	17
GSA10_200-500	26	27	26	26	27	26	26	28	22	22	22	22	22	22	22	22
GSA10_500-800	31	30	31	31	31	30	31	29	26	27	26	26	26	26	26	26

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.35.3.1.2. Geographical distribution patterns

Data on the the geographical distribution pattern of pink shrimp come from studies conducted in the area using trawl-survey data, length frequency distribution analyses and geostatistical methods (Lembo *et al.*, 2000a). The indicator kriging approach combined with a persistence analysis showed that the nurseries of the pink shrimp were localised with higher level of probability offshore Cape Bonifati (Calabria coasts) Napoli and Salerno Gulfs between 100 and 200 m depth (Fig. 5.35.3.1.2.1).

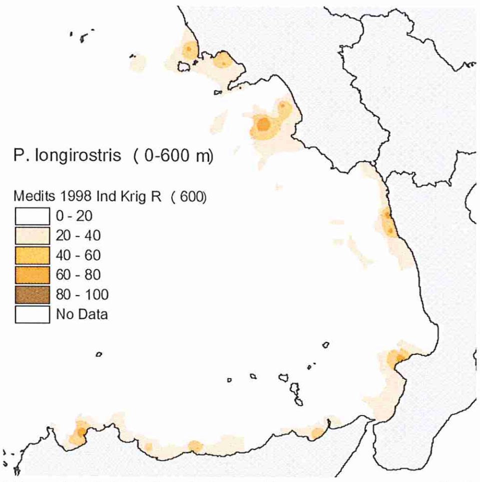


Fig. 5.35.3.1.2.1 Map of nursery area of pink shrimp.

5.35.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of pink shrimp in GSA 10 was derived from the international survey Medits. Figure 5.35.3.1.3.1 displays the estimated trend of *P. longirostris* abundance and biomass standardized to the surface unit in GSA 10. Indices from Medits trawl-surveys show two peaks in 1999 and 2005, but without any trend. From 2005 onwards the indices are decreasing and commercial catches follow a similar pattern.

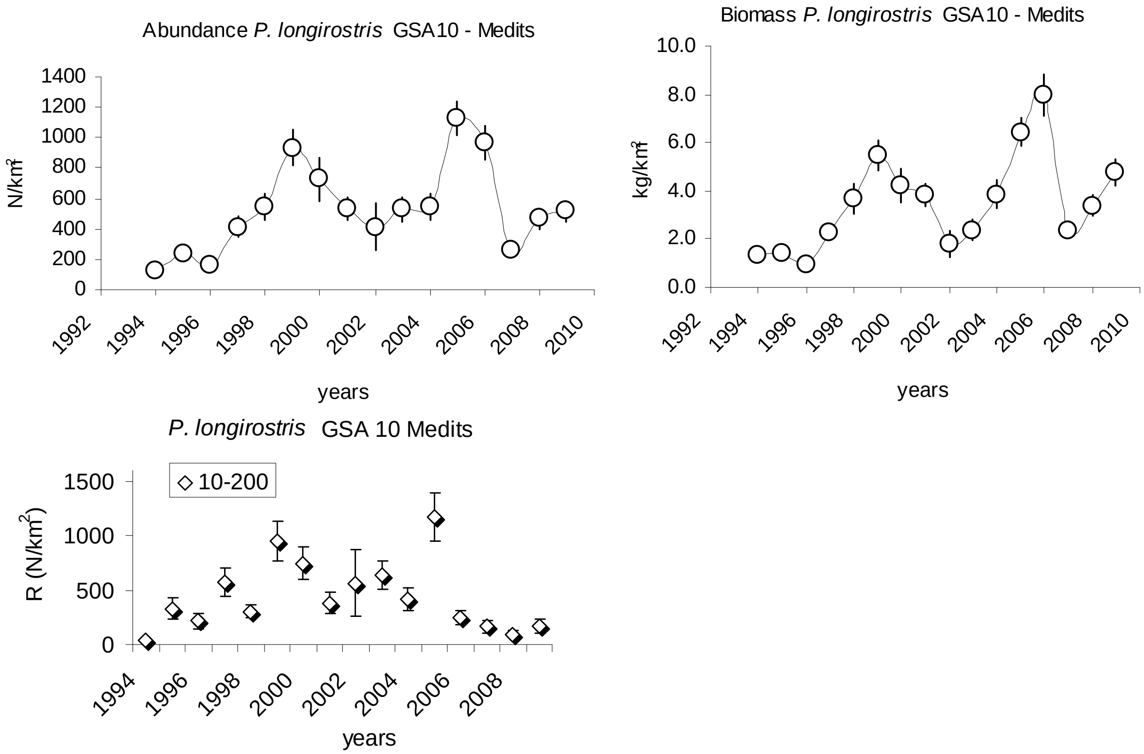


Fig. 5.35.3.1.3.1 Trends in survey abundance and biomass indices standardized to the surface unit and derived from MEDITS (bars indicate standard deviations). Abundance of recruits is also reported.

The re-estimated abundance indices (Figure 5.35.3.1.3.2) show the same temporal pattern.

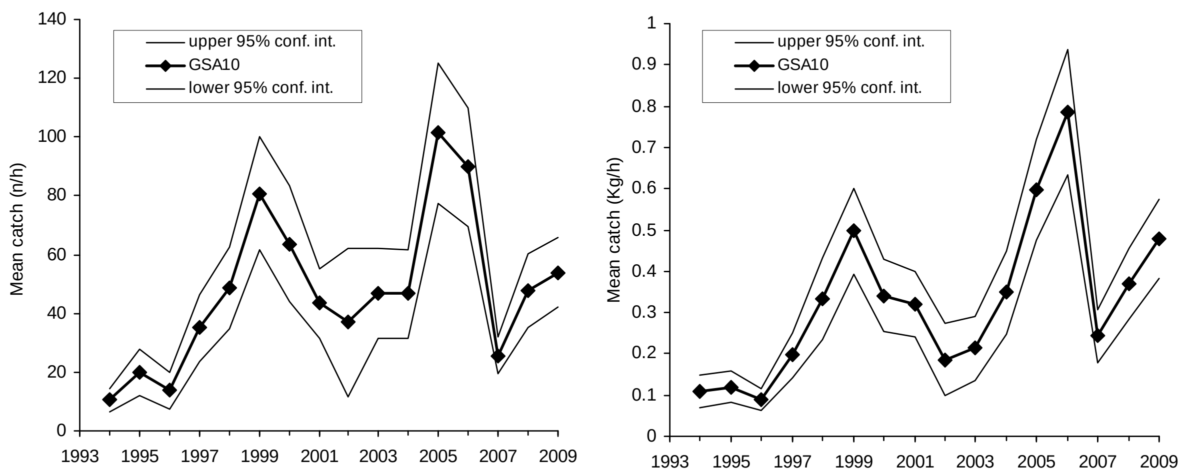


Fig. 5.35.3.1.3.2 Trends in survey abundance and biomass indices (MEDITS) of pink shrimp in GSA 10.

5.35.3.1.4. Trends in abundance by length or age

The following Fig. 5.35.3.1.4.1 and 2 display the stratified abundance indices of GSA 10 in 1994-2001 and 2002-2009. These size compositions are considered preliminary.

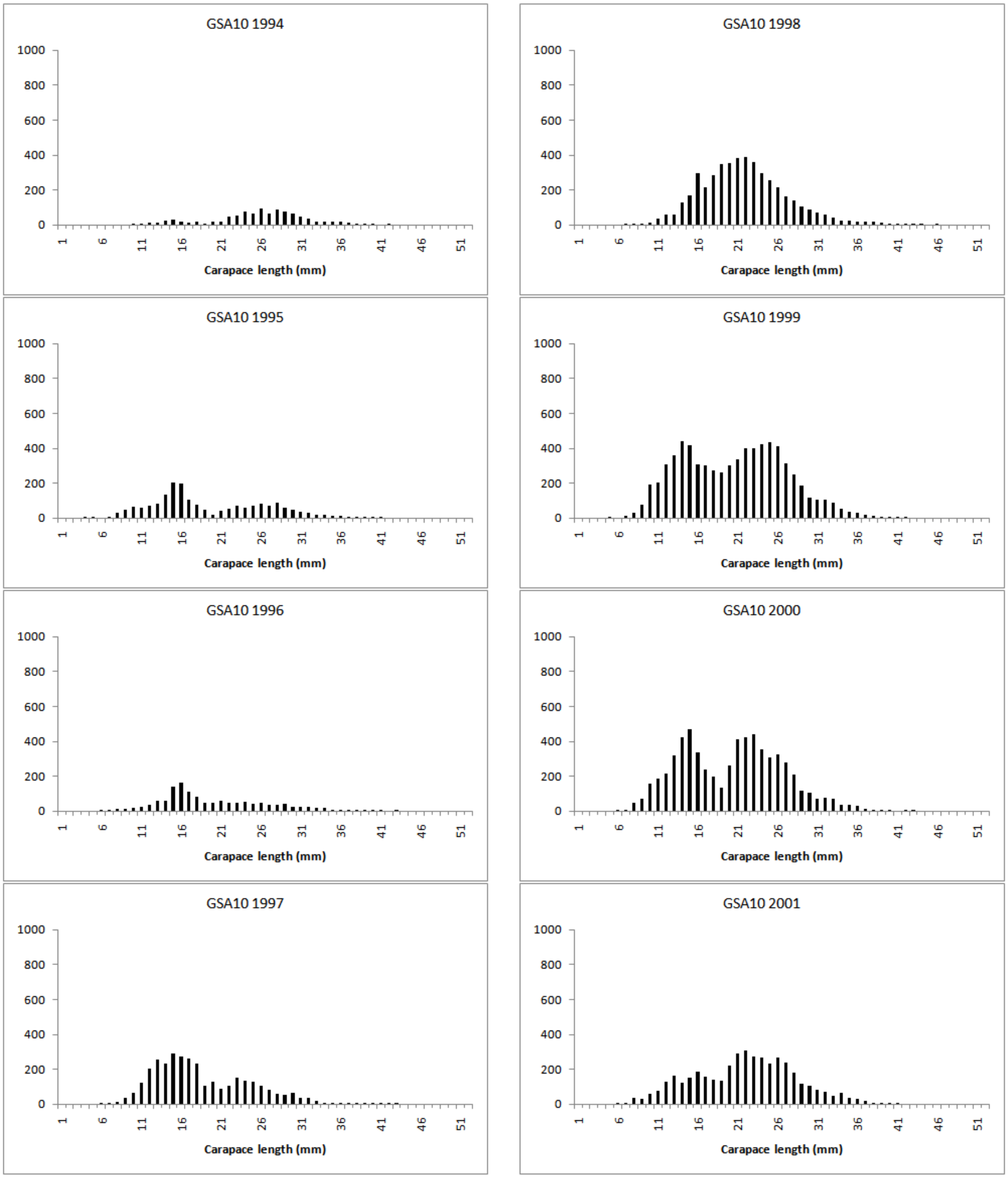
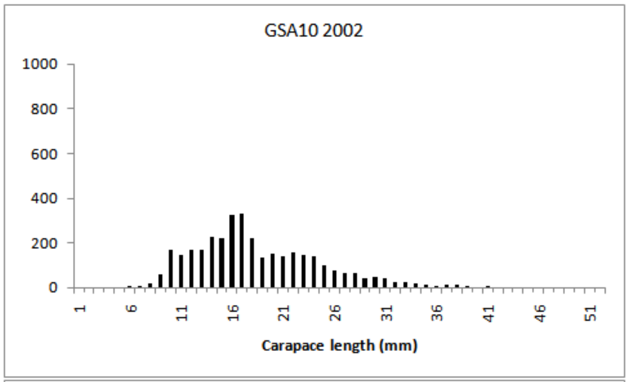
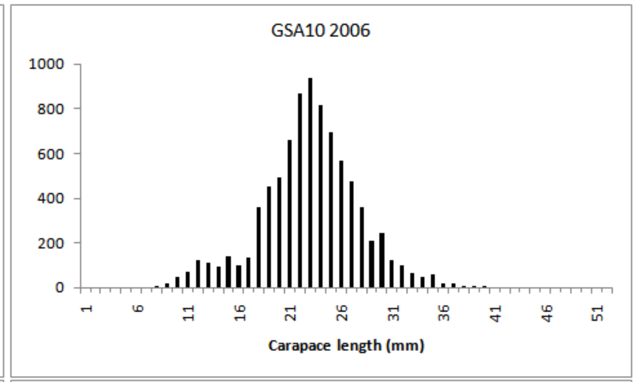
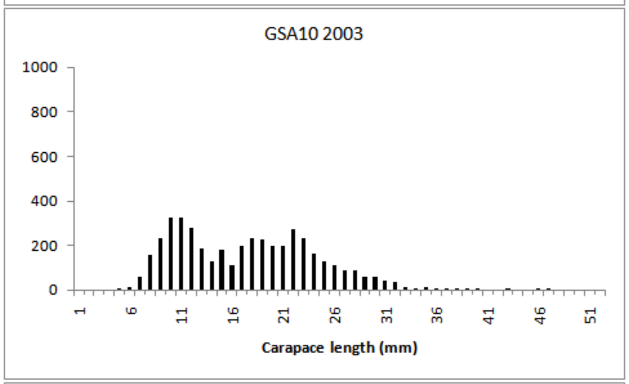
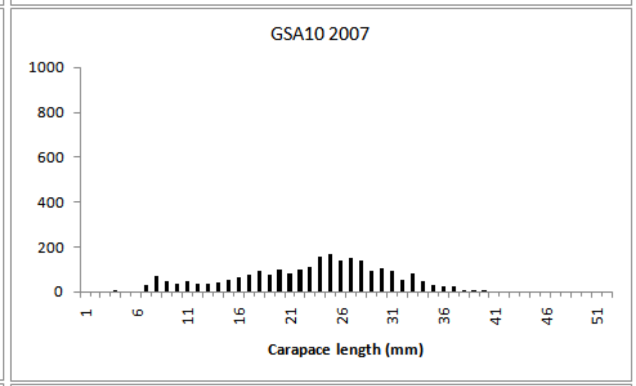


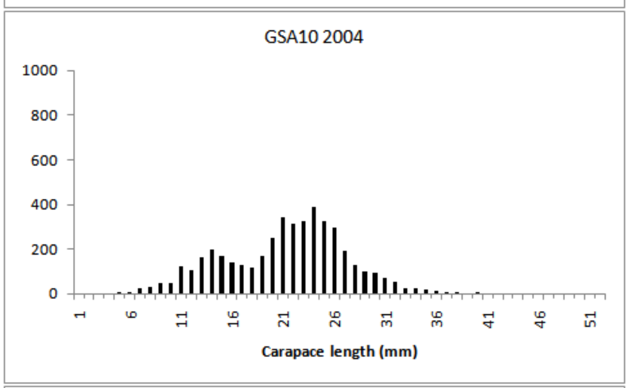
Fig. 5.35.3.1.4.1 Stratified abundance indices by size, 1994-2001.

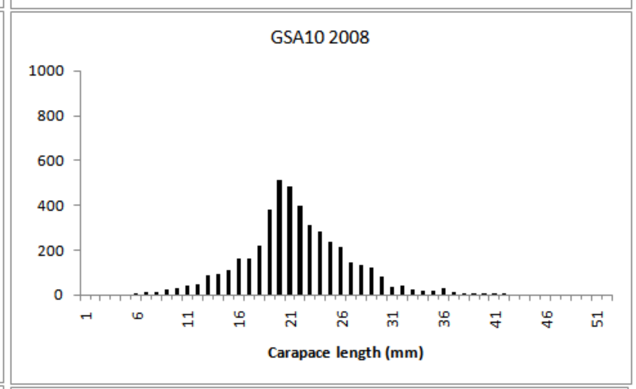

GSA10 2002
1000
800
600
400
200
0
1
6
11
16
21
26
31
36
41
46
51
Carapace length (mm)

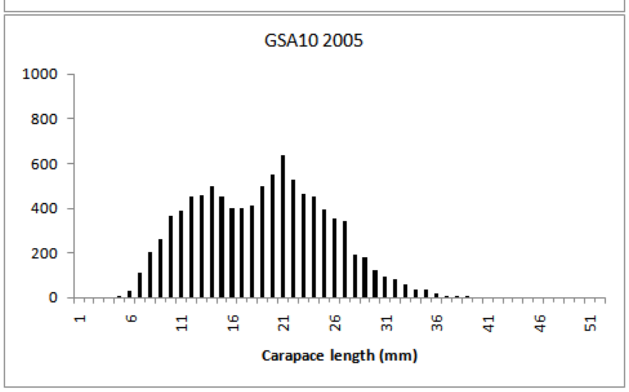

GSA10 2006
1000
800
600
400
200
0
1
6
11
16
21
26
31
36
41
46
51
Carapace length (mm)


GSA10 2003
1000
800
600
400
200
0
1
6
11
16
21
26
31
36
41
46
51
Carapace length (mm)


GSA10 2007
1000
800
600
400
200
0
1
6
11
16
21
26
31
36
41
46
51
Carapace length (mm)


GSA10 2004
1000
800
600
400
200
0
1
6
11
16
21
26
31
36
41
46
51
Carapace length (mm)


GSA10 2008
1000
800
600
400
200
0
1
6
11
16
21
26
31
36
41
46
51
Carapace length (mm)


GSA10 2005
1000
800
600
400
200
0
1
6
11
16
21
26
31
36
41
46
51
Carapace length (mm)

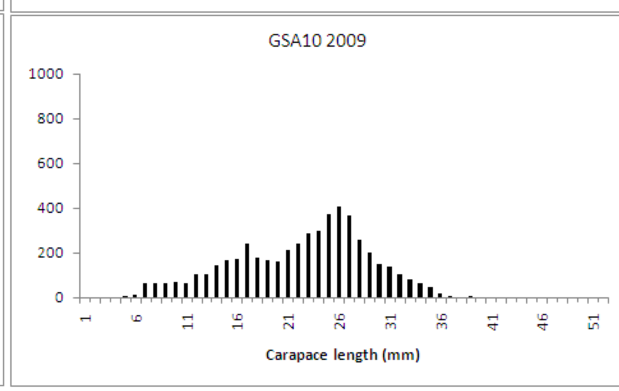

GSA10 2009
1000
800
600
400
200
0
1
6
11
16
21
26
31
36
41
46
51
Carapace length (mm)

Fig. 5.35.3.1.4.2 Stratified abundance indices by size, 2002-2009.

No trend in the mean length was observed in MEDITS survey (Fig. 5.35.3.1.4.3), neither in any other length indicators.

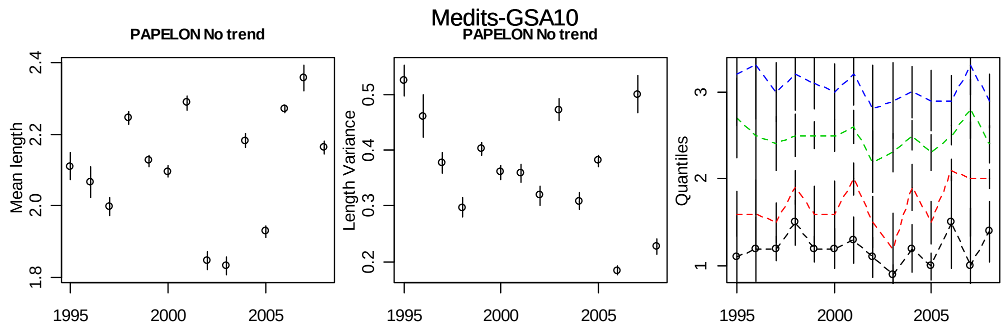


Fig. 5.35.3.1.4.3 Mean length, variance and quantiles derived from the MEDITS length compositions.

5.35.3.2. GRUND

5.35.3.2.1. Methods

GRUND survey trends were estimated and are shown in the following sections.

5.35.3.2.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.35.3.2.3. Trends in abundance by length or age

Trends derived from the GRUND surveys are shown in Fig. 5.35.3.2.3.1. Abundance and biomass indices as well as recruitment indices, show an increasing trend up to 2005 and a decreasing since 2006 (Fig. 5.35.3.2.3.1). In 1999 the survey was not performed.

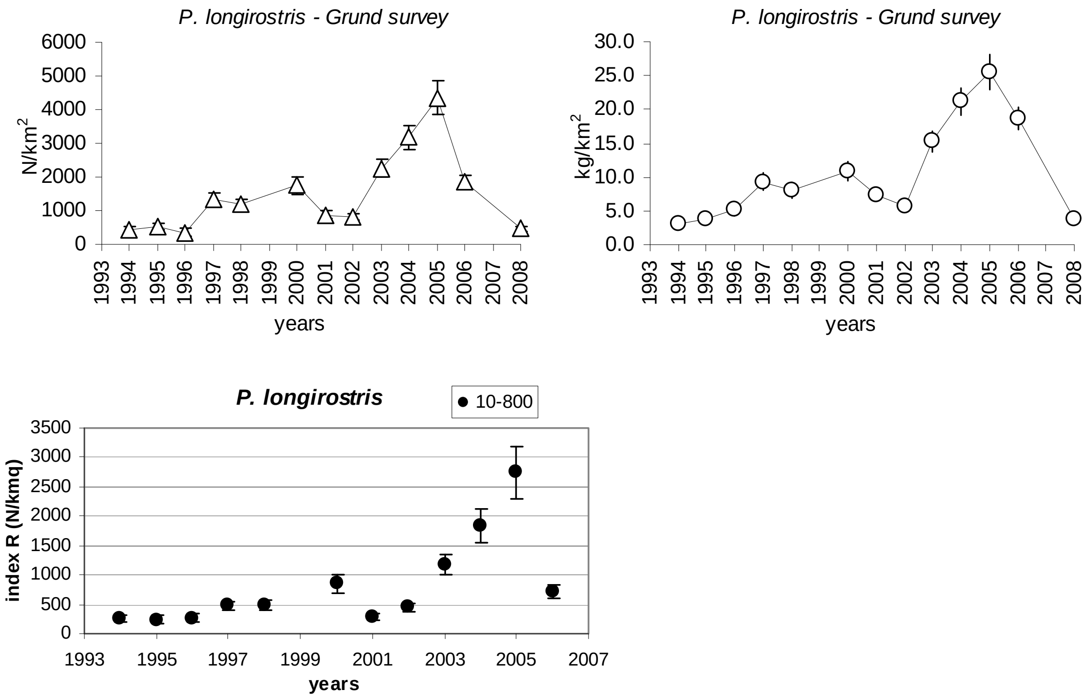


Fig. 5.35.3.2.3.1 Abundance and biomass indices of the pink shrimp in GSA 10 (bars indicate standard deviations) derived from GRUND surveys. Recruitment indices (n/km^2) computed in the total depth range with standard deviation is also reported.

5.35.3.2.4. *Trends in abundance by length or age*

Also time series of length structures of GRUND from 1994 to 2006 (Fig. 5.35.3.2.4.1) did not show any trend.

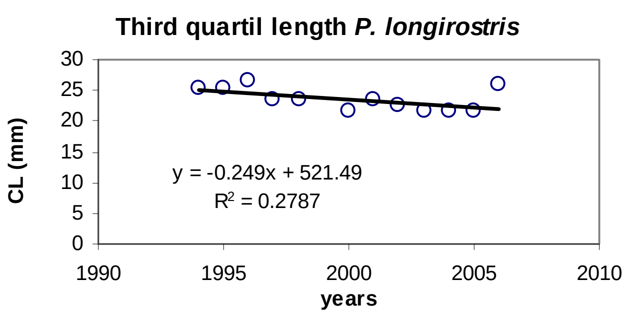


Fig. 5.35.3.2.4.1 III Quantile derived from the GRUND length structures in 1994-2006.

5.35.3.2.5. *Trends in growth*

No analyses were conducted during SGMED-10-02.

5.35.3.2.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.35.4. Assessment of historic stock parameters

SGMED-10-02 applied the VIT model to commercial landings.

5.35.4.1.Method 1: VIT

5.35.4.1.1. Justification

VIT software was applied using landings data of 2006-2008. Three analyses were performed (one for each year) in order to overcome the limitation of equilibrium condition hypothesis in VPA technique, then VIT and YIELD results were compared.

5.35.4.1.2. Input parameters

A sex combined analysis was carried out using females growth parameters:
CL_{∞} = 4.6 cm, K= 0.575, t_0= -0.2; length-weight relationship: a = 0.935, b = 2.4523.
Constant natural mortality M = 0.9 (Alagaraja (1984) estimates averaged between males and females) and terminal fishing mortality F_{term}= 1 were assumed.

Table 5.35.4.1.2.1 Landings in numbers at length (thousands) in 2006, 2007 and 2008.

	Year		
Age	**2006**	**2007**	**2008**
0	70,208.34	32,219.58	38,654.72
1	57,746.67	6,399.05	16,094.80
2	1,122.57	375.12	281.16
3		5.28	1.07

5.35.4.1.3. Results

Estimates of total and fishing mortality at age for sex combined by VIT are plotted in the Fig. 5.35.4.1.3.1.

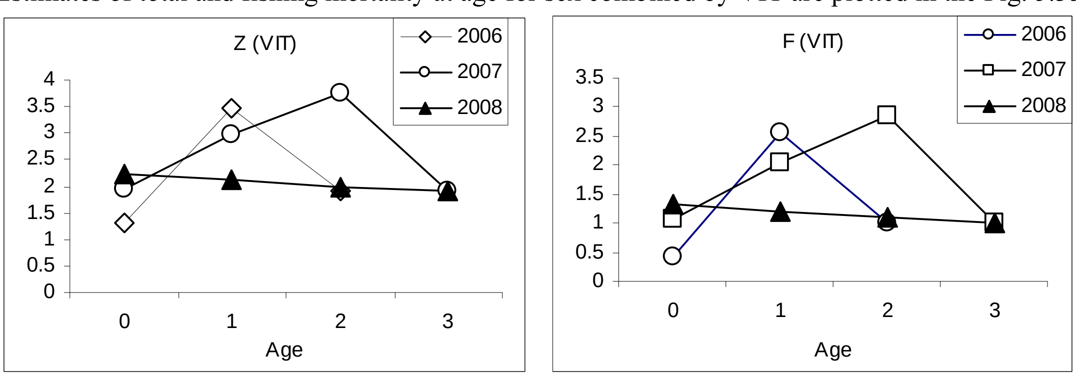


Fig. 5.35.4.1.3.1. Total and fishing mortality by age as estimated by the cohort analysis using VIT, by year (2006-2008).

Table 5.35.4.1.3.1 Estimated stock parameters for 2006, 2007 and 2008.

2006	Factor	F	Y/R	B/R	SSB
F(0)	0	0	0	7.045	6.108
F(0.1)	0.59	0.78411	2.418	2.936	2.173
Fmax	0.85	1.12965	2.497	2.317	1.609
Fcurr	1.01	1.329	2.479	2.046	1.371
Fdouble	2	2.658	2.131	1.216	0.701
2007	Factor	F	Y/R	B/R	SSB
F(0)	0	0	0	8.303	7.366
F(0.1)	0.34	0.59296	2.121	3.518	2.799
Fmax	0.5	0.872	2.205	2.665	2.02
Fcurr	1.01	1.744	1.934	1.331	0.875
Fdouble	2	3.488	1.358	0.554	0.304
2008	Factor	F	Y/R	B/R	SSB
F(0)	0	0	0	8.303	7.366
F(0.1)	0.47	0.5452	1.78	3.104	2.495
Fmax	0.62	0.7192	1.822	2.423	1.882
Fcurr	1.01	1.16	1.68	1.331	0.939
Fdouble	2	2.32	1.163	0.446	0.253

5.35.5. Long term prediction

Two assessment approaches were applied for long term predictions, the VIT and secondly the YIELD software.

5.35.5.1. Method 1: VIT

5.35.5.1.1. Justification

The VIT results regarding the long term prediction are presented below.

5.35.5.1.2. Input parameters

Input parameters are given in section 5.35.4.1.2 on the VIT assessment above.

5.35.5.1.3. Results

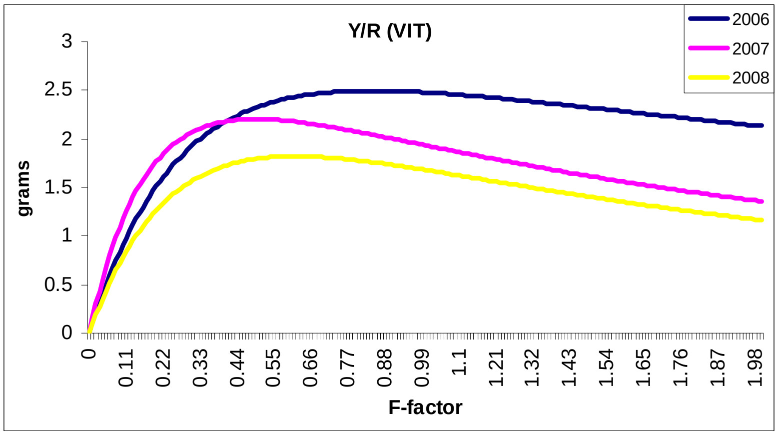


Fig. 5.35.5.1.3.1 Y/R curves for 2006-2008.

Tab. 5.35.5.1.3.1 Overall results of Y/R analysis for 2006-2008.

Year	Fcurr	Y/R	F0.1	Y/R	Fmax	Y/R	Z
2006	1.329	2.479	0.78411	2.418	1.12965	2.497	2.229
2007	1.744	1.934	0.59296	2.121	0.872	2.205	2.644
2008	1.16	1.68	0.5452	1.78	0.7192	1.822	2.06

5.35.5.2. Method 2: YIELD

5.35.5.2.1. Justification

A yield per recruit analyses was conducted also using the Yield software, in order to obtain a point estimate with the associated variability for the reference point to be used in the advice.

5.35.5.2.2. Input parameters

The same growth and natural mortality parameters used in VIT were also the input to Yield. The parameters were however converted in TL (growth parameters and length-weight relationship coefficients) in order to parameterize the YIELD software: TL_∞ = 20.77 cm, K= 0.575, t_0= -0.23, a= 0.0178, b= 2.5423. The conversion from CL to TL was obtained by the following relationship: TL=2.98+4.47*CL, from Crosnier *et al*., 1970.

Both total length at first maturity of 8.13 cm (normally distributed, coefficient of variation (CV)= 0.01), according to the maturity ogive derived in the area and a total length at first capture of 6.57 cm (normally distributed, CV=0.01) were entered in YIELD software. Finally, it was fixed a constant recruitment of 182 million individuals (CV=0.2) that was derived averaging the 2006-2008 age 0 classes computed by VIT.

5.35.5.2.3. Results

The results from Yield analysis are reported in Tab. 5.35.5.2.3.1.

Tab. 5.35.5.2.3.1. Results of Y/R analysis from YIELD.

$F_{0.1}$	Y/R kg	Fmax	Y/R kg
0.65	0.002	1.24	0.002

5.35.6. Data quality

Landings from 2009 were not submitted by the Italian authorities. Due to lack of numbers-at-age or numbers-at-length from the landings the update of the VIT assessment in 2009 was therefore not carried out. Analysis of the effort data were not updated. All other data available at SGMED-10-02 have been used. The most updated series from trawl survey was up to 2009. A check of hauls allocation between GSA 9 and 10 needs to be done before calculation of indices from JRC MEDITS database. Data on maturity and growth have also been used. Information from GRUND surveys and studies on nursery in the GSA have also been included.

5.35.7. Scientific advice

5.35.7.1. Short term considerations

5.35.7.1.1. State of the spawning stock size

In the absence of proposed and agreed precautionary management references, SGMED-10-02 is unable to fully evaluate the status of SSB. Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. MEDITS indices indicate a sharp decrease from 2006 to 2007 and then a slight increase. GRUND data showed a recent decrease of abundance and biomass from 2005 to 2006 after a rising phase.

5.35.7.1.2. State of recruitment

Recruitment estimates from GRUND surveys showed a decrease in abundance from 2005 to 2006 after a rising phase from 2002 to 2005.

5.35.7.1.3. State of exploitation

SGMED-10-02 proposes $F \leq 0.65$ as limit management reference point (basis $F_{0.1}$) of exploitation consistent with high long term yield. Given the results of the present analysis, the stock is considered overexploited during the period 2006-2008. SGMED recommends the relevant fleets' effort to be reduced to reach the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan.

5.36. Stock assessment of pink shrimp in GSA 11

5.36.1. Stock identification and biological features

5.36.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.36.1.2. Growth

No information was documented during SGMED-10-02.

5.36.1.3. Maturity

No information was documented during SGMED-10-02.

5.36.2. Fisheries

5.36.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.36.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.36.2.3. Catches

5.36.2.3.1. Landings

Tab. 5.36.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. No data were reported for 2009. Since 2004 the annual landings varied, reaching 552 t in 2005 and decreasing to 45 t in 2008. The landings were mainly taken by demersal otter trawls.

Tab. 5.36.2.3.1.1 Annual landings (t) by fishing technique in GSA 11, 2004-2008.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	11	ITA	GTR	DEMSP					4	3			
DPS	11	ITA	OTB	DEMSP				45	46	23	1	5	
DPS	11	ITA	OTB	DWSP								0	
DPS	11	ITA	OTB	MDDWSP				187	502	104	78	40	
Sum								232	552	130	79	45	

5.36.2.3.2. Discards

No information was documented during SGMED-10-02.

5.36.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.36.2.3.3.1. No data were provided for 2009.

Tab. 5.36.2.3.3.1 Trends in annual fishing effort by fishing technique deployed in GSA 11, 2004-2008.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
11	ITA	FPO	DEMSP		VL0006					8227	1107	
11	ITA	FPO	DEMSP		VL0612				13379	69823	43856	
11	ITA	FPO	DEMSP		VL1218					16165	4731	
11	ITA	FYK	DEMSP		VL0006						0	
11	ITA	GNS	DEMSP		VL0006				0	3950	2439	
11	ITA	GNS	DEMSP		VL0612		22701	54787	5413	44336	35469	
11	ITA	GNS	DEMSP		VL1218		5248	39173	9568	7130	19593	
11	ITA	GTR	DEMSP		VL0006				5465	5988	4328	
11	ITA	GTR	DEMSP		VL0612			38115	82656	176487	116844	
11	ITA	GTR	DEMSP		VL1218		1814	54332	19069	75188	64023	
11	ITA	LHP-LHM	CEP		VL0006					4305	1131	
11	ITA	LHP-LHM	CEP		VL0612		3065		2611	9764	3353	
11	ITA	LHP-LHM	CEP		VL1218					12237	4371	
11	ITA	LHP-LHM	FINF		VL0612						3480	
11	ITA	LLD	LPF		VL1218			6694				
11	ITA	LLD	LPF		VL2440					1975		
11	ITA	LLS	DEMF		VL0006				228	2263	0	
11	ITA	LLS	DEMF		VL0612		50046	61709	4253	76836	29234	
11	ITA	LLS	DEMF		VL1218		3499	34499	20040	43290	25525	
11	ITA	LLS	DEMF		VL2440					13170		
11	ITA	OTB	DEMSP		VL1218		75568	77835	108842		95470	
11	ITA	OTB	DEMSP		VL1824						66067	
11	ITA	OTB	DEMSP		VL2440						22082	
11	ITA	OTB	MDDWSP		VL1218					152444	8561	
11	ITA	OTB	MDDWSP		VL1824		115969	188926	141391	195889	35045	
11	ITA	OTB	MDDWSP		VL2440		213246	234872	190232	187054	126564	
11	ITA	PS	SPF		VL1218		4109					

5.36.3. Scientific surveys

5.36.3.1. Medits

5.36.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 11 the following number of hauls was reported per depth stratum (s. Tab. 5.36.3.1.1.1).

Tab. 5.36.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18
GSA11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20
GSA11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24
GSA11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19
GSA11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

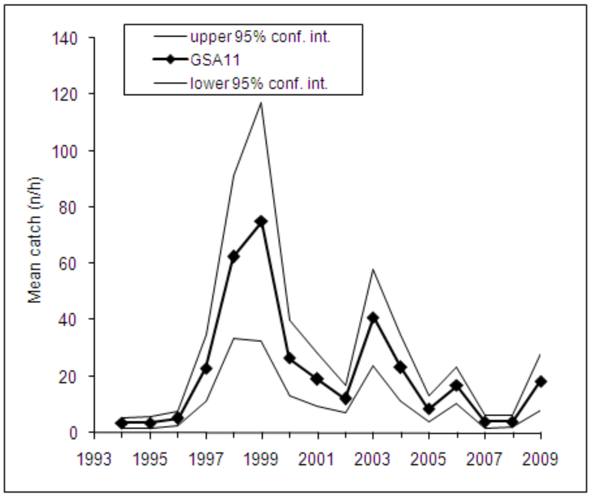
5.36.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.36.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the pink shrimp in GSA 11 was derived from the international survey Medits. Figure 5.36.3.1.3.1 displays the estimated trend in pink shrimp abundance and biomass in GSA 11.

The estimated abundance and biomass indices peaked in 1998-1999 and 2003. However, the recent abundance and biomass indices since 2005 appear low.



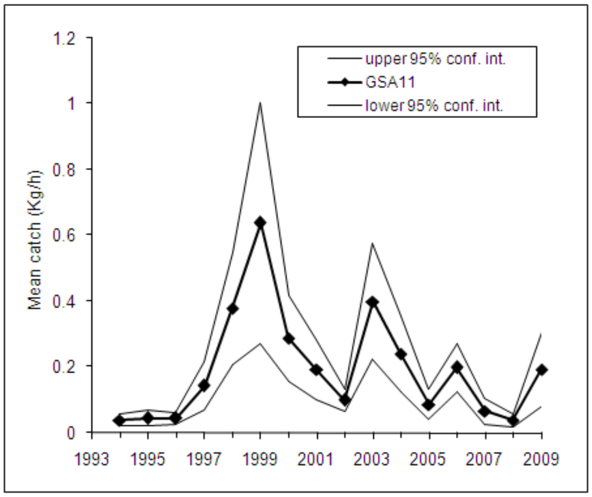


Fig. 5.36.3.1.3.1 Abundance and biomass indices of pink shrimp in GSA 11.

5.36.3.1.4. Trends in abundance by length or age

The following Fig. 5.36.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2001 and 2002-2009. These size compositions are considered preliminary.

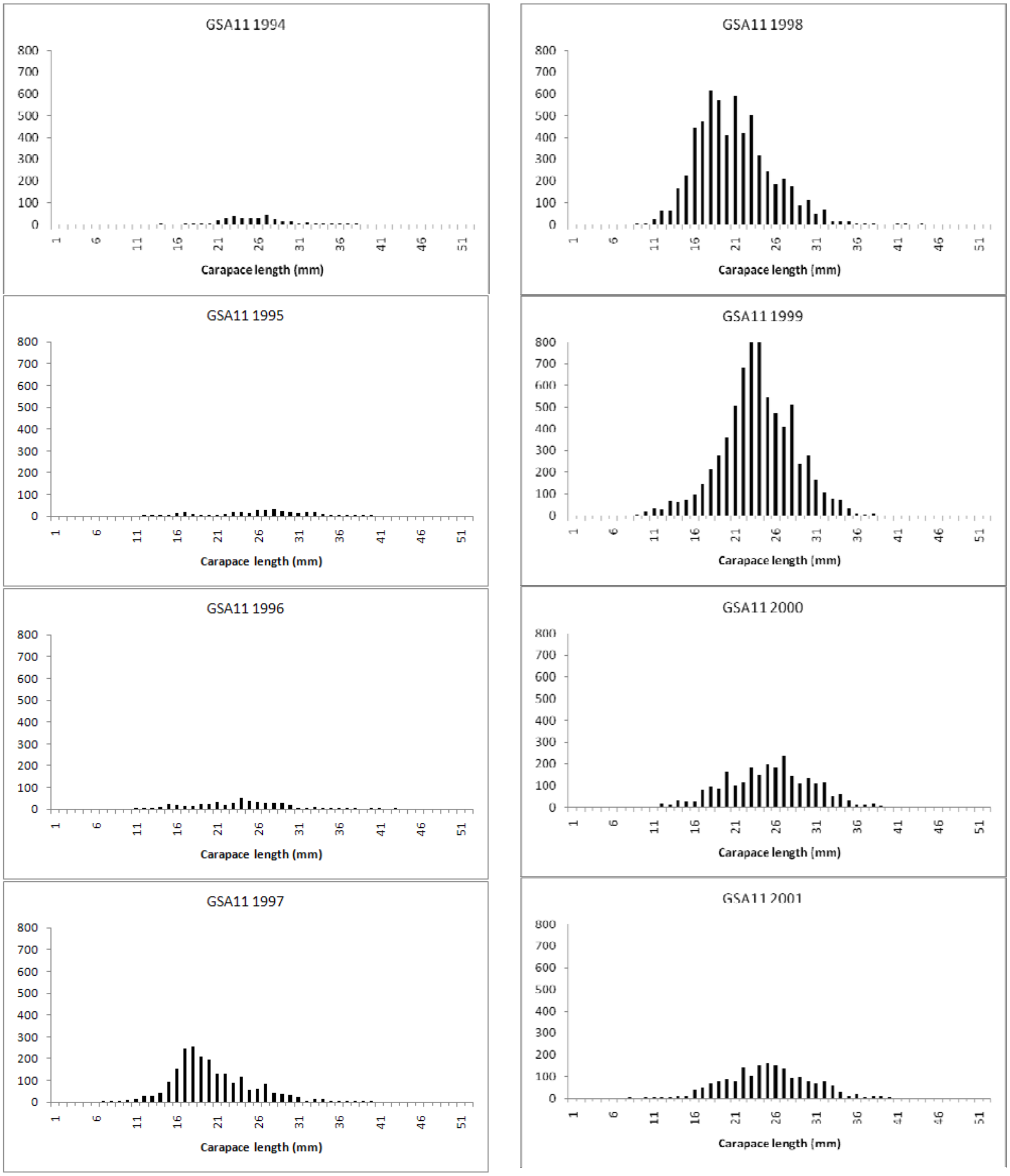


Fig. 5.36.3.1.4.1 Stratified abundance indices by size, 1994-2001.

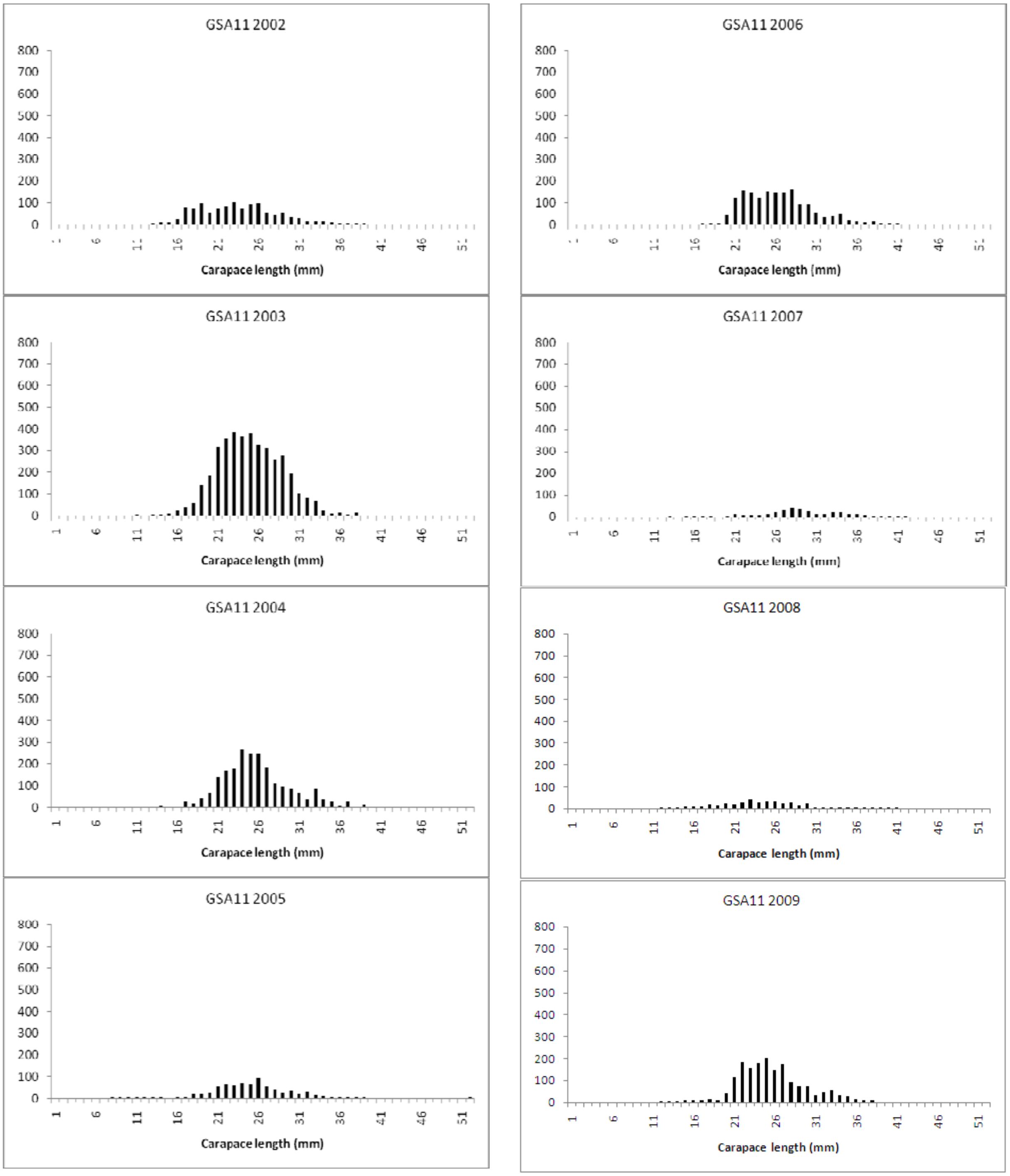


Fig. 5.36.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.36.3.1.5. *Trends in growth*

No analyses were conducted during SGMED-10-02.

5.36.3.1.6. *Trends in maturity*

No analyses were conducted during SGMED-10-02.

5.36.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.36.5. Long term prediction

5.36.5.1. Justification

No forecast analyses were conducted.

5.36.5.2. Input parameters

No forecast analyses were conducted.

5.36.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for pink shrimp in GSA 11.

5.36.6. Scientific advice

5.36.6.1. Short term considerations

5.36.6.1.1. State of the spawning stock size

In the absence of proposed or agreed management reference points SGMED-10-02 is unable to fully evaluate the stock and provide any scientific advice of the state of the spawning stock in relation to them. The recent abundance and biomass indices since 2005 appear low.

5.36.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.36.6.1.3. State of exploitation

In the absence of proposed or agreed management reference points SGMED-10-02 is unable to fully evaluate the stock and provide any scientific advice of the state of the spawning stock in relation to them.

5.37. Stock assessment of pink shrimp in GSAs 15 and 16

5.37.1. Stock identification and biological features

5.37.1.1. Stock Identification

The stock structure of deep water pink shrimp (*Parapenaeus longirostris*) in the Strait of Sicily has not been defined. Levi *et al*. (1995) hypothesised that there is a flux of eggs, larvae and juvenile *P. longirostris* from east to west due to an intermediate water current present in the region. More recently, the existence of at least two sub-populations in the northern side of the area (GSA 15 and 16) were reported by Fortibuoni *et al*. (2010). This idea is based on the occurrence of local spawning and nursery areas, which are connected by the Atlantic Ionian Stream flow (0-150 m depth). It is hypothesised that the development of larval and juveniles phases occurs in this Atlantic Ionian Stream. These local sub-populations, one on the Adventure Bank and one on the Malta Bank, are separated by a wide area, where the species abundance is scanty (Fig. 5.37.1.1.1).

The maximum observed lengths in GSA 15 and 16 recorded during trawl surveys over the last 14 years were 46 and 41 mm CL for females and males respectively (Sinacori G., pers. com.). Although very small specimens were caught in trawl surveys samples, with a recorded minimum sample size of 5 mm CL (Sinacori G., pers. com.), full recruitment to the bottom occurs at 17 mm and 18 mm for females and males respectively in GSAs 15 and 16 (Samed, 2002).

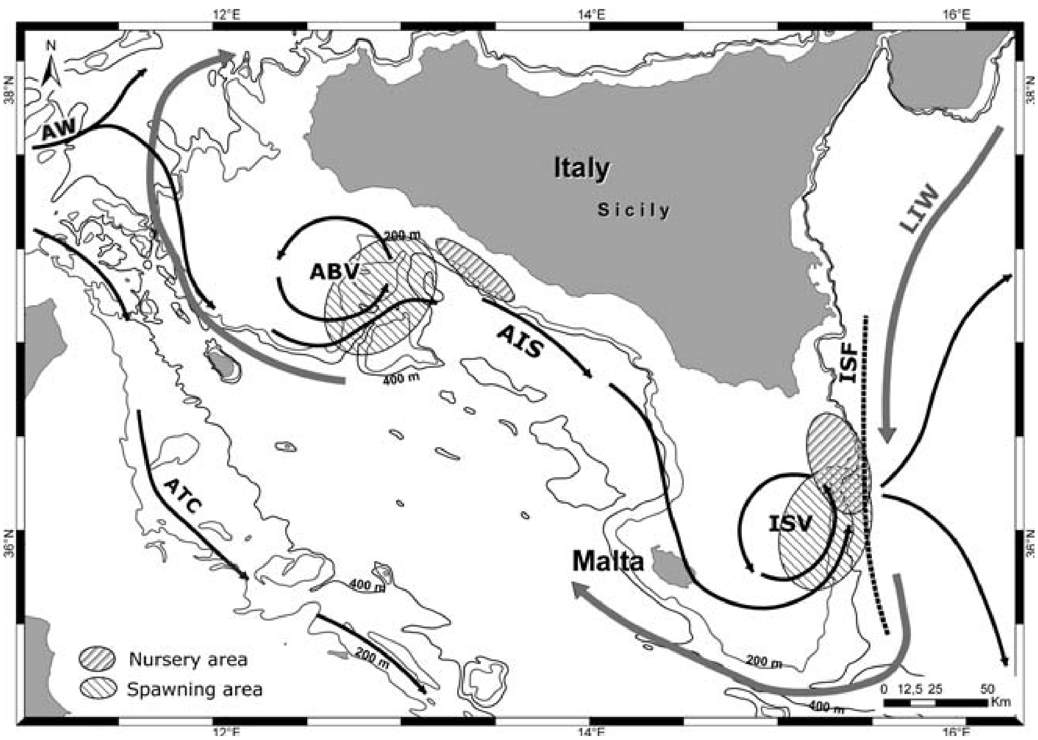


Fig. 5.37.1.1.1 Schematic model of the spawning strategy of *Parapenaeus longirostris* in the northern sector of the Strait of Sicily. The location of stable nursery and spawning areas is shown, as well as the main hydrological characteristics of the area. ABV: Adventure Bank Vortex; ATC: Atlantic Tunisian Current; AIS: Atlantic Ionian Stream; ISV: Ionian Shelf-break Vortex; ISF: Ionian Slope Front; LIW: Levantine Intermediate Water; AW: Atlantic Water (from Fortibuoni et al., 2010).

On the basis of trawl surveys carried out in the northern side of the Strait in GSA 16, sex ratios have remained stable and close to 0.5 (Fiorentino *et al.*, 2005). The sex ratio in weight from commercial landings (2006-2007) as F/(M+F) is 0.66.

In GSA 16, a significant increase in the sex ratio with shrimp size can be observed, with the number of males prevailing in the sampled population from 16 to 22 mm CL, whereas females were more abundant at carapace lengths exceeding 24 mm (SAMED, 2002).

5.37.1.2. Growth

An updated review of information on pink shrimp growth and natural mortality parameters in the Strait of Sicily can be found in Fiorentino *et al*. (2008). Since the objective of the present assessment was to assess stock status by combining sexes, growth parameters as well as a vector of maturity by size were obtained by weighing values by size with the sex ratio in each size class (Fig. 5.37.1.3.1). The adopted Von Bertalanffy growth function (VBGF) parameters were L_{inf} = 44.29, K = 0.628 and t_0= -0.205. The length-weight relationship (LWR) parameters were a=0.0033 and b= 2.4572.

5.37.1.3. Maturity

According to Levi *et al*. (1995) mature females are found in GSA 15 and 16 throughout the year, with a maturity peak extended from November to February, and another maturity peak in April. The lowest percentage of mature females appeared in June-July, but continuous spawning seems to occur. Ben Mariem et al. (2001) reported that *P. longirostris* off the Tunisian coasts (GSA 12) reproduces all year along, with a peak in June-July and a minimum in winter.

The most recent maturity oogive parameters are: $L_{50\%}$ of 22.1 mm CL, and a corresponding slope value of 0.45 in females, $L_{50\%}$ of 14.3 mm CL, and a corresponding slope value of 1.5 in males (CNR-IAMC, 2007). The vector of percentage of mature for combined sex (values by sex averaged by sex ratio weighting) is reported in Fig. 5.37.1.3.1.

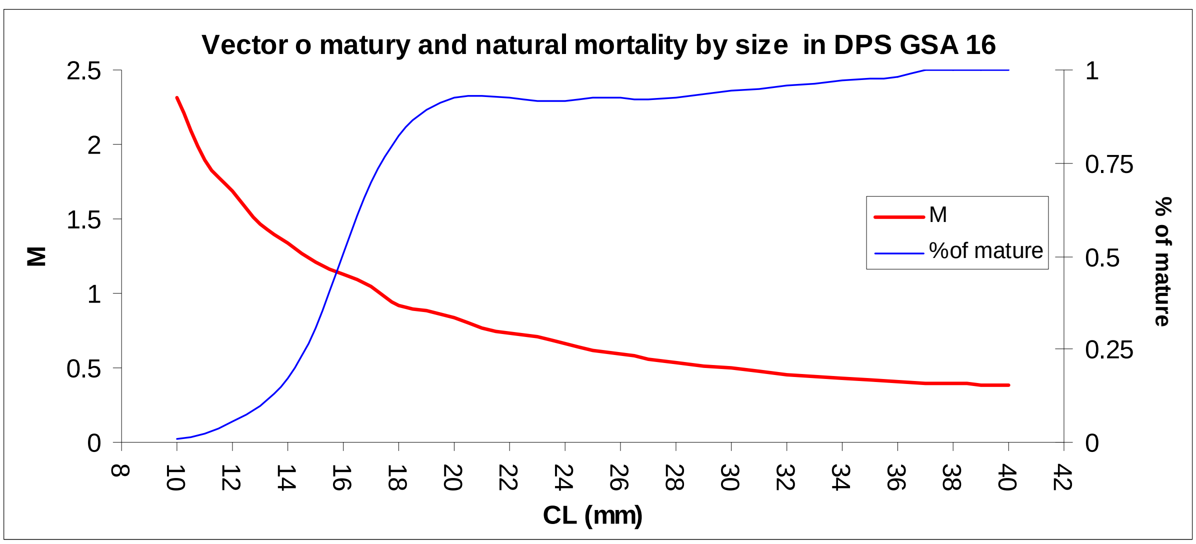


Fig. 5.37.1.3.1 Maturity and natural mortality (M) by size of *P. longirostris* in the Strait of Sicily. The M vector, was estimated according to Caddy and Abella (1999). A scalar value of M was also estimated as the arithmetic mean of the values by size (M= 0.85).

5.37.2. Fisheries

5.37.2.1. General description of fisheries

P. longirostris is fished exclusively by otter trawl vessels, together with other species (*Nephrops norvegicus, Merluccius merluccius, Eledone sp., Illex coindetii, Todaropsis eblanae, Lophius sp., Mullus sp., Pagellus* *sp., Zeus faber* and *Raja sp.*). In fact, deep water pink shrimp are the main target of the Sicilian trawlers, and are caught both on the shelf and on the upper slope throughout the year. However a peak in landings can be observed from March to July.

Sicilian trawlers between 12 – 24m LOA which target deep water pink shrimp are based in seven harbours along the southern coasts of Sicily. These trawlers (about 150 boats in 2009) operate mainly on a short-distance trawl fishery basis, with trips from 1 to 2 days at sea, fishing on outer shelf and upper slope. The distant trawlers of Mazara del Vallo (about 140 boats in 2009) represent the main commercial fleet of trawlers in the area, and are one of the most important fleets in the Mediterranean. In contrast to the other Sicilian fleets, the large trawlers of the Mazara fleet (LOA>24m) are employed on long fishing trips (3 – 6 weeks) in offshore waters. These vessels thus operate in both national and international waters in the Strait of Sicily and adjacent sea.

The main fishing grounds of Sicilian trawlers which target deep water pink shrimp are shown in Fig. 5.37.2.1.1. In addtion to these fishing grounds, since 2004 a number of distant trawlers also operate in the Aegean and Levant Sea, where they however mainly target red shrimp (Garofalo *et al*., 2007).

Following the recent increase in fuel costs, a critical phase has begun for the deep water pink shrimp fishing industry. This has mainly affected the distant fleet, which needs about 1 ton of fuel per day during a fishing trip.

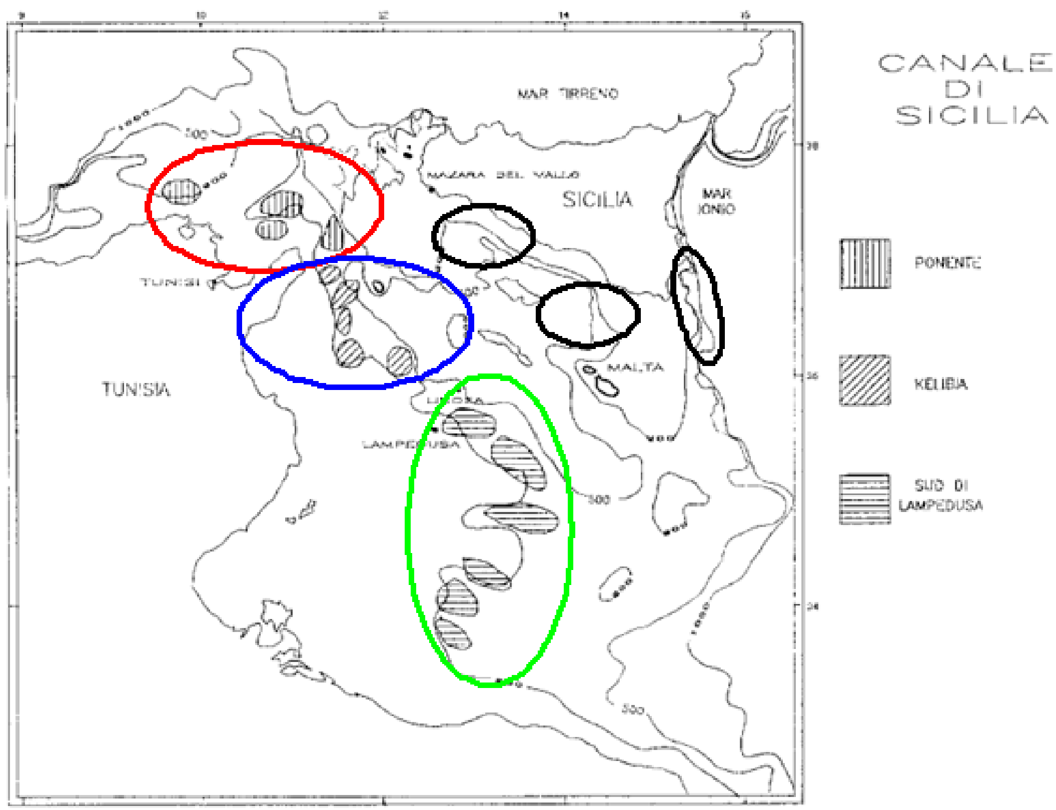


Fig. 5.37.2.1.1 The main fishing areas of *P. longirostris* for distant (coloured) and coastal (black) Sicilian trawlers in the Strait of Sicily (modified from Levi *et al*., 1995).

5.37.2.2. Management regulations applicable in 2009 and 2010

At present there are no formal management objectives for deep water pink shrimp fisheries in the Strait of Sicily. As in other areas of the Mediterranean, stock management measures are based on the control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06).

In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties. After 2000, in agreement with the European Common Policy of Fisheries, a gradual decreasing of the fleet capacity is occurring. Furthermore from 1987 to 2005 a 30-45 days ban of fishing activities was enforced each year, although in different ways, in order to reduce fishing effort. In 2009 a medium term management plan has been agreed for Italian trawlers catching hake in GSA 15 and 16 including a fleet reduction of 25% of the current capacity obtained in two steps. The first (12.5%) from 2008 to 2010, and the second (12.5%) from 2011 to 2013.

In terms of technical measures, the Reg EC 1967 of 21 December 2006 fixed a new minimum mesh size for bottom trawling of EU fishing vessels (Italian and Maltese trawlers): square 40 mm or diamond 50 mm. By June 2009 no derogations are possible in adopting the new minimum mesh size. The same regulation fixed a minimum landing size for *P. longirostris* which is 20 mm carapace length (Annex III, EC 1967/2006).

A further and more effective improvement in the exploitation pattern of deep water pink shrimp might be obtained through an integrative technical measure having a similar effect to the increasing of mesh size, i.e. the protection of pink shrimp nurseries. Differently from red mullet, whose nurseries are in the already protected bottoms within three nautical miles from the coast, the location of deep water pink shrimp nurseries are on discrete off-shore areas on the outer shelf (100-200 m), partially in international waters, making the possibility of protecting the nursery areas a difficult task especially with respect to enforcement. These nurseries are impacted almost exclusively by trawlers with LOA < 24 m which operate in more coastal waters.

It must be outlined the existence in the Strait of Sicily of the Maltese FMZ (GSA 15) which extends up to 25 nautical miles from baselines around the Maltese islands. Here fishing effort and capacity are being managed by limiting vessel sizes, as well as total vessel engine powers (EC 813/04; EC 1967/06). Trawling is allowed within this designated conservation area, however only by vessels not exceeding an overall length of 24m and only within designated areas. Such vessels fishing in the management zone hold a special fishing permit in accordance with Article 7 of Regulation (EC) No 1627/94, and are included in a list containing their external marking and vessel's Community fleet register number (CFR) to be provided to the Commission annually by the Member States concerned. Moreover, the overall capacity of the trawlers allowed to fish in the 25 nm zone can not exceed 4 800 kW, and the total fishing effort of all vessels is not allowed to exceed an overall engine power and tonnage of 83 000 kW and 4 035 GT respectively. The fishing capacity of any single vessel with a license to operate at less than 200 m depth can not exceed 185 kW. In addition, the use of all trawl nets within 1.5 nm of the coast is prohibited according to EC regulation 1967/2006, although again a transitional derogation is at present in place until 2010. There are no closed seasons in Maltese waters.

5.37.2.3. Catches

5.37.2.3.1. Landings

The estimation of yearly overall landings from Sicilian trawlers which perform fishing trips with a 1-2 day duration ranged between 1290 and 1640 tons (Andreoli et al., 1995) in the mid 1980s. The estimation of yearly overall yields of the Mazara distant fleet in late 1980s and in the early 1990s ranged between 2360 and 5180 tons (Levi *et al.*, 1995).

Table 5.37.2.3.1.1 Landings (t) of deep water pink shrimp by small (12m<LOA<24m) and large (LOA>24m) trawlers from official DCF data. No data submitted for 2009.

	LOA 12-24	LOA >24	total
2002	4052	3373	7425
2003	2964	4502	7466
2004	2976	3689	6665
2005	4430	4154	8584
2006	4536	3920	8456
2007	3869	2097	5966
2008	3734	2207	5941

Estimation of the absolute cathes in numbers, harvested by Italian trawlers in the Strait of Sicily in 2006-2008 for the two operational units ($LOA_{12\text{-}24}$ and $LOA_{>24}$) are distinguished under the EU DCF. Total landings data was thus separated according to vessel lengths.

Considering that the overall trawl yield (all species combined) was about 9,666 tons in 2006 and 8,052 tons in 2007, deep water pink shrimp landings represent about 74-87% of the area's total yield. It is important to note that landings of deep water pink shrimp in Sicilian ports do not derive solely from GSA 16, but also from GSA 15 and other adjacent GSAs of the Strait of Sicily.

According to the available data, from 2002 and onwards, the total yield of the Sicilian boats fishing in the Strait of Sicily (inshore as well as distant fisheries) ranged from 8600 tons in 2006, and 5900 tons in 2008 (IREPA data).

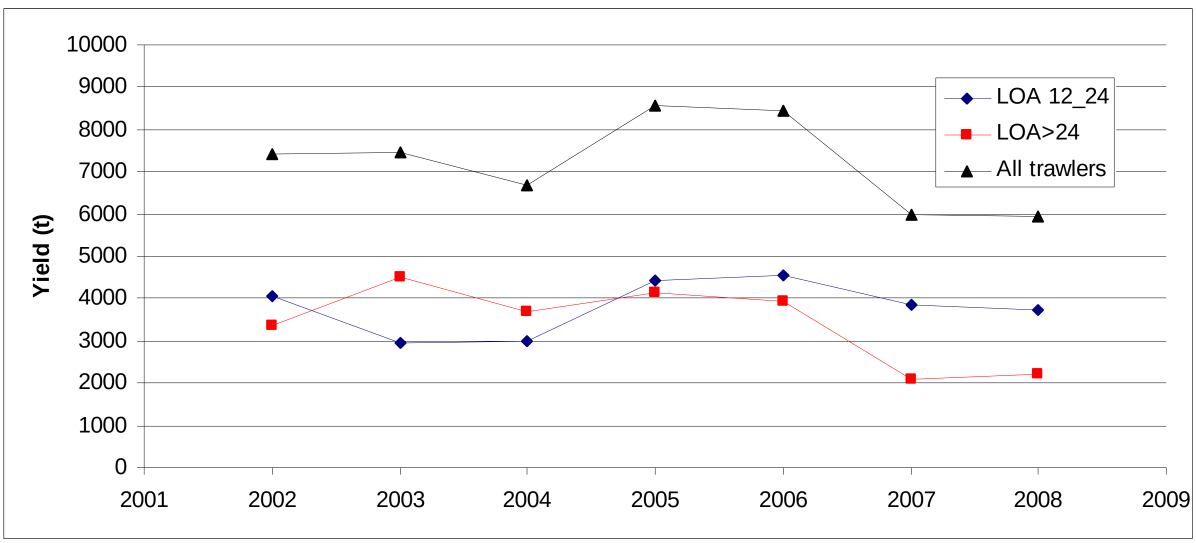


Fig. 5.37.2.3.1.1 Landings of Sicilian trawlers based in GSA 16, throughout the Strait of Sicily.

From these figures, it is evident the difference in catch size between trawlers smaller and larger than 24 m, with the former fleet segment catching shrimps smaller than the minimum legal size.

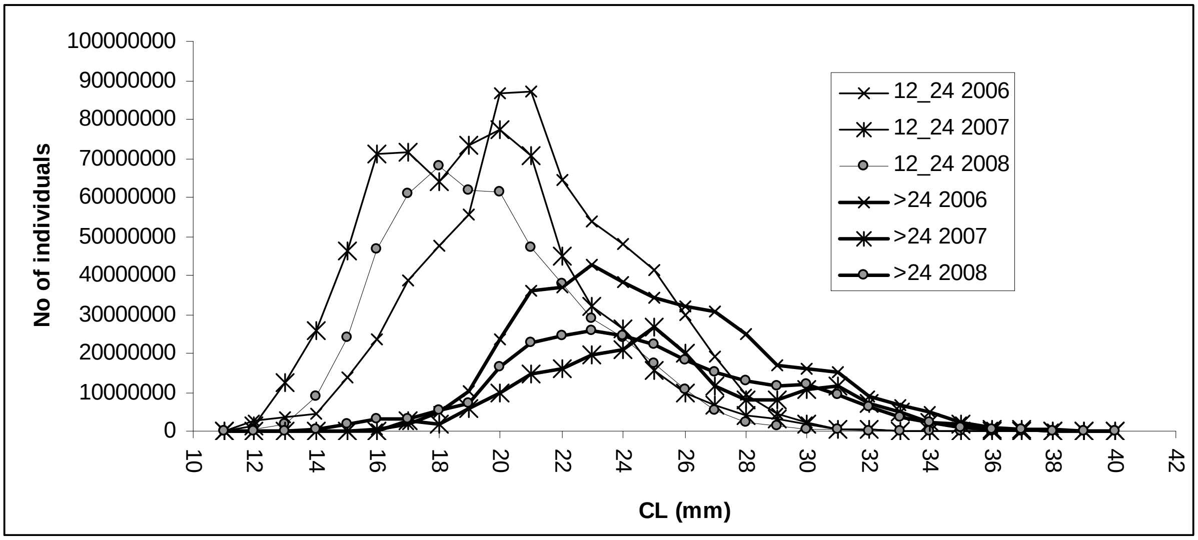


Fig. 5.37.2.3.1.2 Estimates of absolute catches in number of Italian trawlers in the Strait of Sicily, 2006, 2007 and 2008. Catches of the two operational units ($LOA_{12\text{-}24}$ and $LOA_{>24}$) are separated.

5.37.2.3.2. Discards

According to Levi *et al*. (1995), the length at 50% capture of 32 mm mesh size trawling, as estimated by using a catch curve was 16.1 mm CL (Selection Factor=0.5). More recently experiments of selectivity for the same mesh size gave a L50%= 13.0±0.1 (mm) (Selection Range=5.2 and SF=0.42) (Ragonese & Bianchini, 2006). Studies on the discarded fraction of trawlers in GSA 16 during 2006 however recorded a length at 50% discard ranging between 14.6 and 17.0 mm CL (Gancitano V., pers. comm.).

The modal size of the catch and discarded fraction of *P. longirostris* of Sicilian trawlers is very variable, changing both with regards to the fishing season and fishing deep ranges (Table 3.37.2.3.2.1). The amount of discards are also variable, with higher discards recorded in autumn-winter, as well as from catches harvested between 150 and 300 m (Anon., 2000).

Table 3.37.2.3.2.1 Modal length (LC in mm) of discarded fraction and landings of *P. longirostris* in typical inshore (Porto Palo- South eastern Sicily) and distant (Mazara del Vallo - South western Sicily) Sicilian trawling fisheries (from Anon., 2000).

	Modal length (mm)	
	discards	landings
Inshore fisheries	12	16 and 19
Distant fisheries	19	25-26

However, it is important to note that in recent years the fraction of discarded fraction is very low, ranging from 18 (2007-2008) to 25 (2006) tons.

5.37.2.3.3. Fishing effort

Fishing effort data from 2009 were not submitted by the Italian authorities. The evolution of fishing capacity in number of trawlers by year is reported in Fig. 5.37.2.3.3.1 below.

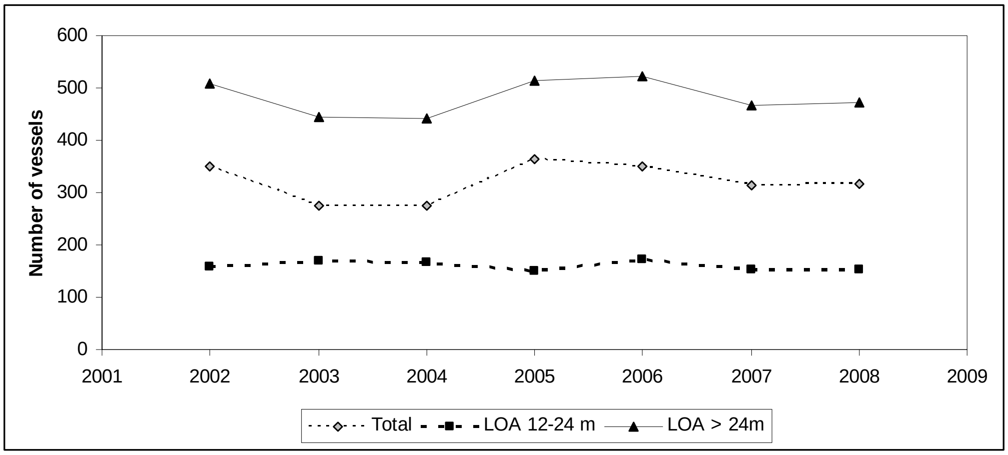


Fig. 5.37.2.3.3.1 Fishing capacity of Sicilian trawlers in number of vessels in the Strait of Sicily

No information on the specific effort of trawling on deep water pink shrimp is available. The trends in overall fishing effort by year and major gear type is listed in Tab. 5.37.2.3.3.1 and shown in Fig. 5.37.2.3.3.2 in terms of kW*days for the otter trawls. Data on fishing effort of Italian trawlers larger than 24 m LOA in 2006 seems to be not consistent with the time series.

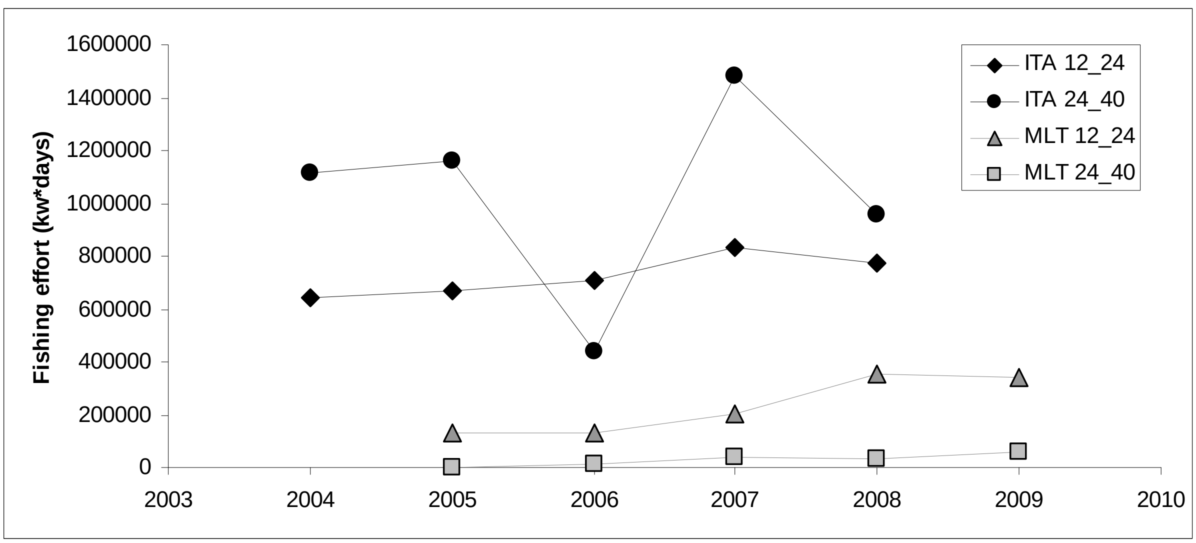


Fig. 5.37.2.3.3.2 Trend in annual effort (kW*days) of the Italian and Maltese otter trawlers operating in the Strait of Sicily, 2004-2009 (2004 data from Malta and 2009 data from Italy not available).

Tab. 5.37.2.3.3.1 Trend in annual effort (kW*days) by fishing segment in GSAs 15 and 16, 2004-2009 as reported through the DCF in 2010. No data reported for 2009 by Italy

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
15	MAL	FPO	DEMF		VL0006							4594
15	MAL	FPO	DEMF		VL0012						49249	
15	MAL	FPO	DEMF		VL0612							27061
15	MAL	FPO	DEMF		VL1224						1522	
15	MAL	GNS	DEMF		VL0012			1830			4379	
15	MAL	GNS	DEMF		VL1224			291				
15	MAL	GNS	DEMF	16D20	VL0006							346
15	MAL	GNS	DEMF	16D20	VL0612							1058
15	MAL	GNS	SLPF	16D20	VL0006							301
15	MAL	GNS	SLPF	16D20	VL0612							909
15	MAL	GTR	DEMF		VL0012			8364	6899	19700	14197	
15	MAL	GTR	DEMF		VL1224			5316	1492	1024	164	
15	MAL	GTR	DEMF		VL2440			209				
15	MAL	GTR	DEMF	16D20	VL0006							1222
15	MAL	GTR	DEMF	16D20	VL0612							2952
15	MAL	LA	SLPF		VL0012				54906	35688	46987	
15	MAL	LA	SLPF		VL0612							65405
15	MAL	LA	SLPF		VL1218							130081
15	MAL	LA	SLPF		VL1224				148455	160497	128657	
15	MAL	LA	SLPF		VL1824							34808
15	MAL	LA	SLPF		VL2440					12272		
15	MAL	LHM	CEP		VL0006							1729
15	MAL	LHM	CEP		VL0012						9497	
15	MAL	LHM	CEP		VL0612							2500
15	MAL	LHM	CEP		VL1224						298	
15	MAL	LHM	FINF		VL0012			5406			67	
15	MAL	LHM	FINF		VL1224			1352				
15	MAL	LHM	LPF		VL0012						9102	
15	MAL	LHM	LPF		VL1224						403	
15	MAL	LLD	LPF		VL0006							1971
15	MAL	LLD	LPF		VL0012			92350		107473	195062	
15	MAL	LLD	LPF		VL0612							202557
15	MAL	LLD	LPF		VL1218							199948
15	MAL	LLD	LPF		VL1224			420481		330062	299467	
15	MAL	LLD	LPF		VL1824							185676
15	MAL	LLD	LPF		VL2440			41731		12365	7811	41358
15	MAL	LLS	DEMF		VL0006							5242
15	MAL	LLS	DEMF		VL0012			47773	82092	81472	141656	
15	MAL	LLS	DEMF		VL0612							101973
15	MAL	LLS	DEMF		VL1218							40027
15	MAL	LLS	DEMF		VL1224			79870	73824	79442	68490	
15	MAL	LLS	DEMF		VL1824							8556
15	MAL	LLS	DEMF		VL2440			13204	3775			634
15	MAL	LTL	LPF		VL0006							1179
15	MAL	LTL	LPF		VL0012			13009	8073			
15	MAL	LTL	LPF		VL0612							3270
15	MAL	LTL	LPF		VL1224			13100	2137			
15	MAL	LTL	LPF		VL2440			209				
15	MAL	OTB	MDDWSP		VL1224			128047	133167	201767	352184	
15	MAL	OTB	MDDWSP		VL2440			1790	10742	39090	30358	
15	MAL	OTB	MDDWSP	40SXX	VL1824							340113
15	MAL	OTB	MDDWSP	40SXX	VL2440							59792
15	MAL	PS	LPF		VL2440						13920	
15	MAL	PS	LPF	14D16	VL2440							15442
15	MAL	PS	SPF		VL0012						6490	
15	MAL	PS	SPF		VL1224						35413	
15	MAL	PS	SPF	14D16	VL0612							373
15	MAL	PS	SPF	14D16	VL1218							14890
15	MAL	PS	SPF	14D16	VL1824							14920
15	MAL	SB-SV	DEMF		VL0006							286
15	MAL	SB-SV	DEMF		VL0012					2343	1334	
15	MAL	SB-SV	DEMF		VL0612							679
15	MAL	SB-SV	DEMF		VL1224					164		
15	MAL	TBB	DEMF		VL0012						493	
15	MAL	TBB	DEMF		VL0612							82
15	MAL	TBB	DEMF		VL1224						1292	
16	ITA				VL0612			3886			417	
16	ITA	GTR	DEMSP		VL0006				8548	9979	12285	
16	ITA	GTR	DEMSP		VL0612		164944	178522	76073	103953	103352	
16	ITA	GTR	DEMSP		VL1218		25926	7720	23894	18868	8189	
16	ITA	GTR	DEMSP		VL1824			1420				
16	ITA	LHP-LHM	CEP		VL0006				525	1162		
16	ITA	LHP-LHM	FINF		VL0612		16931	16553	14973	15019	21934	
16	ITA	LHP-LHM	FINF		VL1218		641					
16	ITA	LLD	LPF		VL1218		12401	3900	2924	3435	16936	
16	ITA	LLD	LPF		VL1824		36304	5756	1029	78320	12919	
16	ITA	LLS	DEMF		VL0006				1022	3942	1394	
16	ITA	LLS	DEMF		VL0612		26733	58661	12698	57631	9512	
16	ITA	LLS	DEMF		VL1218		21984	1640	3115	62773	18439	
16	ITA	LLS	DEMF		VL1824		1870					
16	ITA	OTB	DEMSP		VL1218		210042	238629	272220		263191	
16	ITA	OTB	DEMSP		VL1824		54367	13425			397440	
16	ITA	OTB	DEMSP		VL2440						693213	
16	ITA	OTB	DWSP		VL1824						15246	
16	ITA	OTB	DWSP		VL2440						41113	
16	ITA	OTB	MDDWSP		VL1218					285378	4336	
16	ITA	OTB	MDDWSP		VL1824		377936	418914	434834	549867	93949	
16	ITA	OTB	MDDWSP		VL2440		1116269	1161841	442196	1484331	225904	
16	ITA	OTM	MDPSP		VL1824				21611	26555	41792	
16	ITA	OTM	MDPSP		VL2440		5306		9096			
16	ITA	PS	LPF		VL1824						9763	
16	ITA	PS	SPF		VL0006						397	
16	ITA	PS	SPF		VL0612			8471		670	3127	
16	ITA	PS	SPF		VL1218		1772	1997	1355		2354	
16	ITA	PS	SPF		VL1824		17339	12429	7349	39307	11625	
16	ITA	PTM	SPF		VL1824			19612	72116	107330	38857	

5.37.3.Scientific surveys

5.37.3.1. Medits

5.37.3.1.1. Methods

In order to collect fisheries independent data, which is a requirement of the EU DCF (Council Regulation 199/2008, Commission Regulation 665/2008, Commission Decision EC 949/2008 and Commission Decision 93/2010), the MEDITS international trawl survey is carried out in GSA 16 on an annual basis. Based on the DCF data call, abundance and biomass indices were recalculated. The following number of hauls was reported per depth stratum in 1994- 2009.

Tab. 5.37.3.1.1.1. Number of hauls per year and depth stratum in GSAs 15 and 16, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA15_010-050									1	2	4	1	1			
GSA15_050-100									6	9	7	5	5	12	6	6
GSA15_100-200									12	23	23	13	13	12	12	15
GSA15_200-500									9	18	16	9	9	4	9	10
GSA15_500-800									18	28	27	17	16	17	17	15
GSA16_010-050	4	4	4	4	4	4	4	4	7	7	7	10	10	11	11	11
GSA16_050-100	9	8	8	8	8	8	7	8	11	12	12	20	22	23	23	23
GSA16_100-200	4	4	4	4	5	5	6	5	11	10	11	20	19	21	21	21
GSA16_200-500	10	11	11	12	11	11	11	11	19	18	26	37	31	27	27	27
GSA16_500-800	10	14	14	13	14	14	14	14	20	20	21	33	33	38	38	38

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:
A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modeled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. ,2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.37.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.37.3.1.3. Trends in abundance and biomass

In addition to information on the trends in pink shrimp abundance in late spring/early summer collected through the MEDITS survey, fisheries independent information was also collected in GSA 16 through the GRUND programme, which is conducted in autumn. Figures 5.37.3.1.3.1 and 5.37.3.1.3.2 display the estimated trend in deep water pink shrimp density and biomass in GSA 16 respectively.

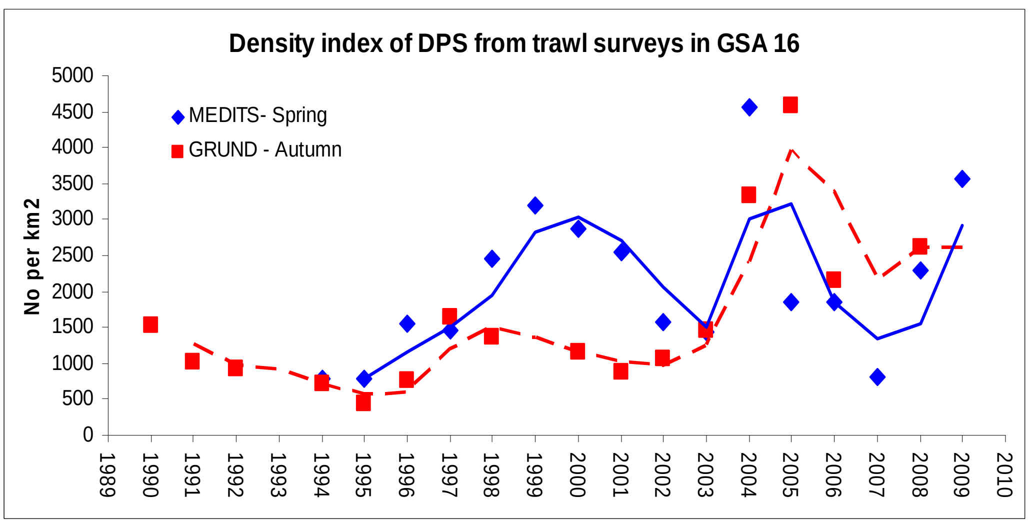


Fig. 5.37.3.1.3.1 Density indices (n per km^2) obtained during the MEDITS and GRUND surveys in GSA 16.

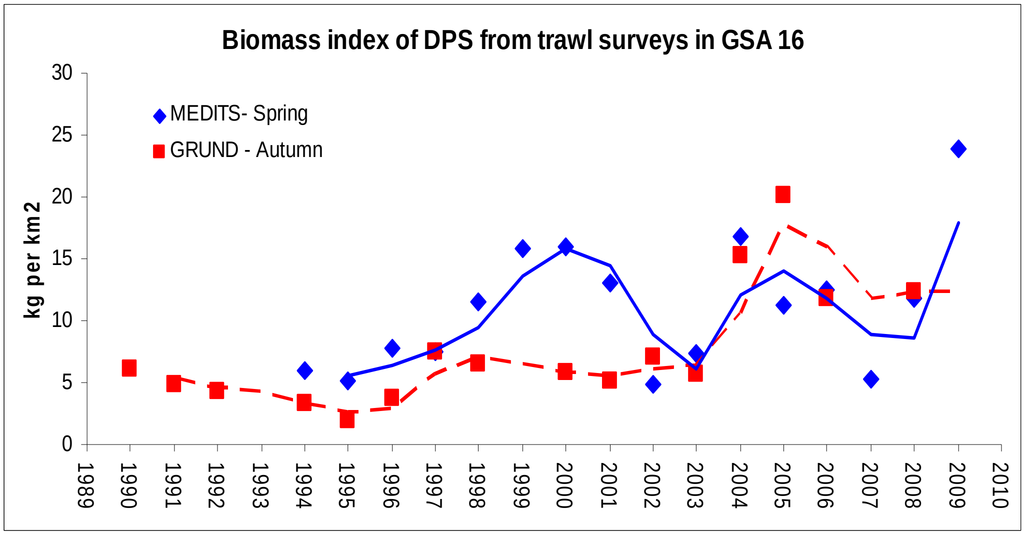


Fig. 5.37.3.1.3.2 Biomass indices (kg per km^2) obtained during the MEDITS and GRUND surveys in GSA 16.

Density indices of recruits (individuals less than 16 mm CL) derived from MEDITS and GRUND trawl surveys were used to describe the variation of recruitment strength in GSA 16. The mean value (± sd) of DI from 1999 to 2009 was 341 ± 463 individuals per km^2 in the Spring (MEDITS) and 258 ± 306 in the Autumn (GRUND).

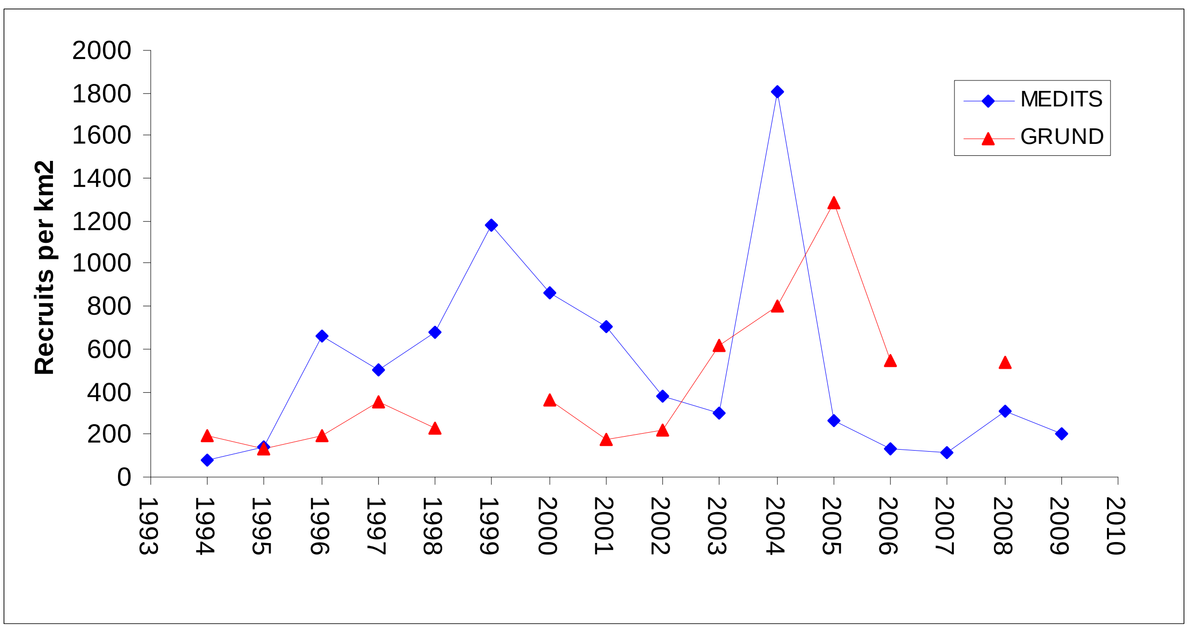


Fig 5.37.3.1.3.3 Index of recruits (individuals < 16mm CL) in number per km^2 of *P. longirostris* in GSA 16.

The trend in abundance and biomass as re-estimated by SGMED-10-02 and are shown in Figures 5.37.3.1.3.4 and 5.37.3.1.3.5 for GSAs 15 and 16. Both areas display a consistent recovery in recent years (2008-2009) from very low levels.

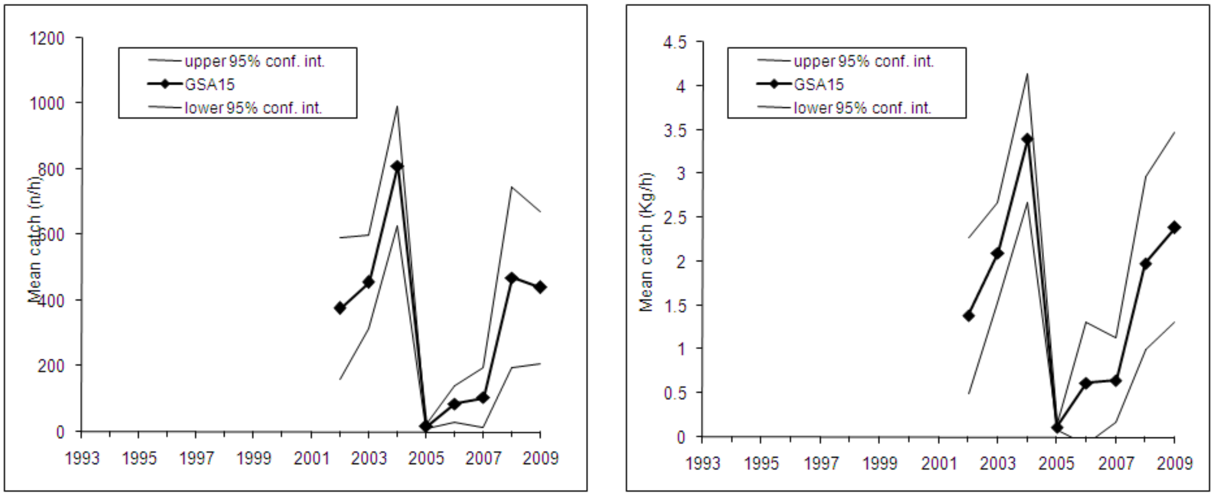


Fig. 5.37.3.1.3.4 Abundance and biomass indices of deep water pink shrimp in GSA 15.

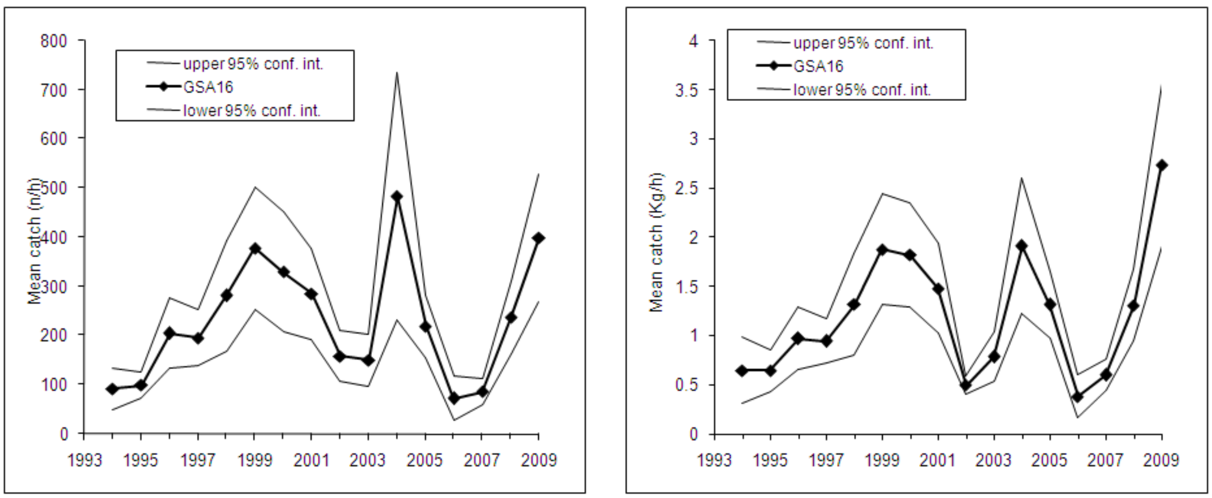


Fig. 5.37.3.1.3.5 Abundance and biomass indices of deep water pink shrimp in GSA 16.

5.37.3.1.4. Trends in abundance by length or age

The following Fig. 5.37.3.1.4.1 displays the stratified abundance indices of GSA 15 in 2002-2009. The Figures 5.37.3.1.4.2 and 5.37.3.1.4.3 display the stratified abundance indices of GSA 16 in 1994-2001 and 2002-2009.

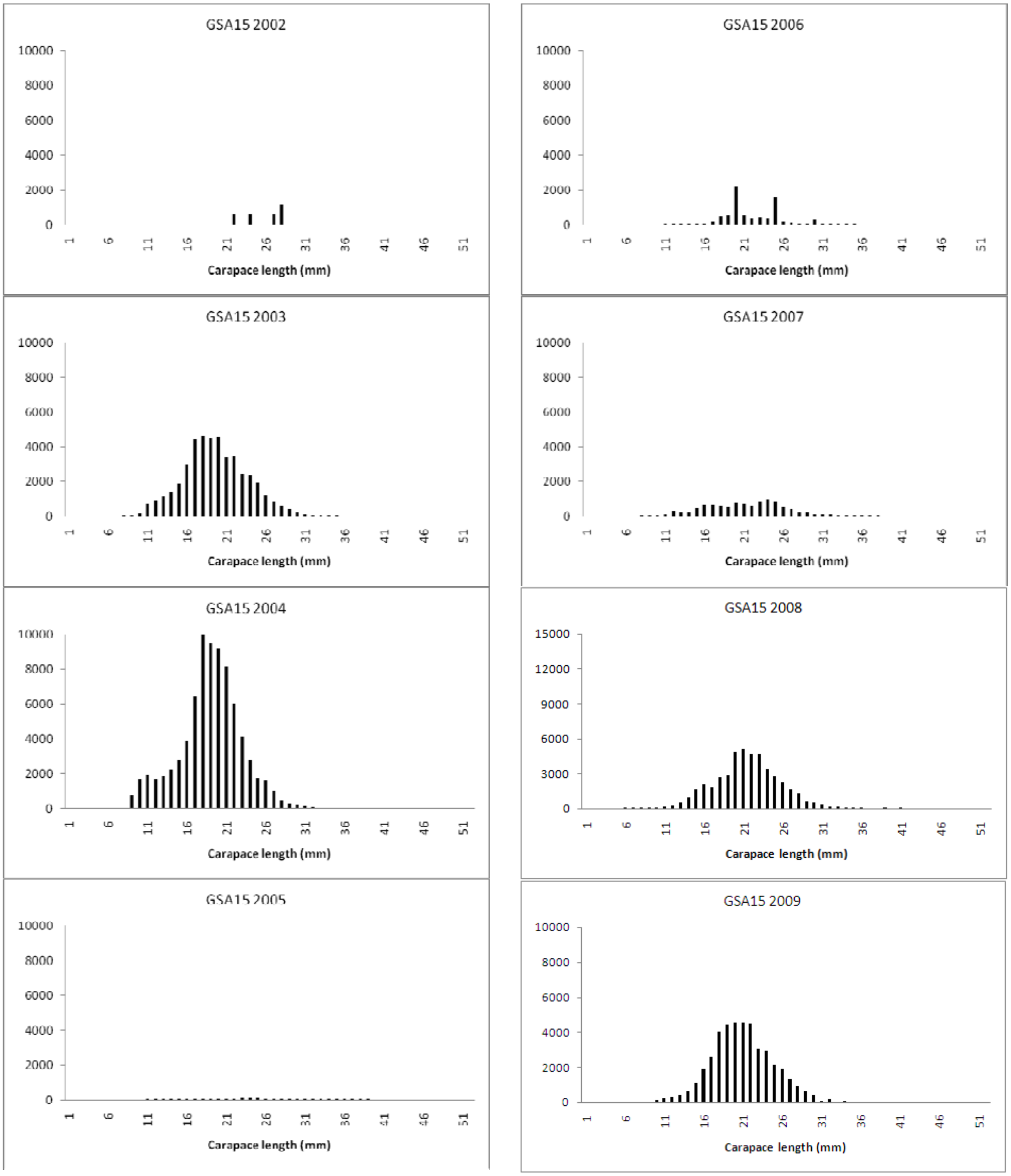


Fig. 5.37.3.1.4.1 Stratified abundance indices by size in GSA 15, 2002-2009.

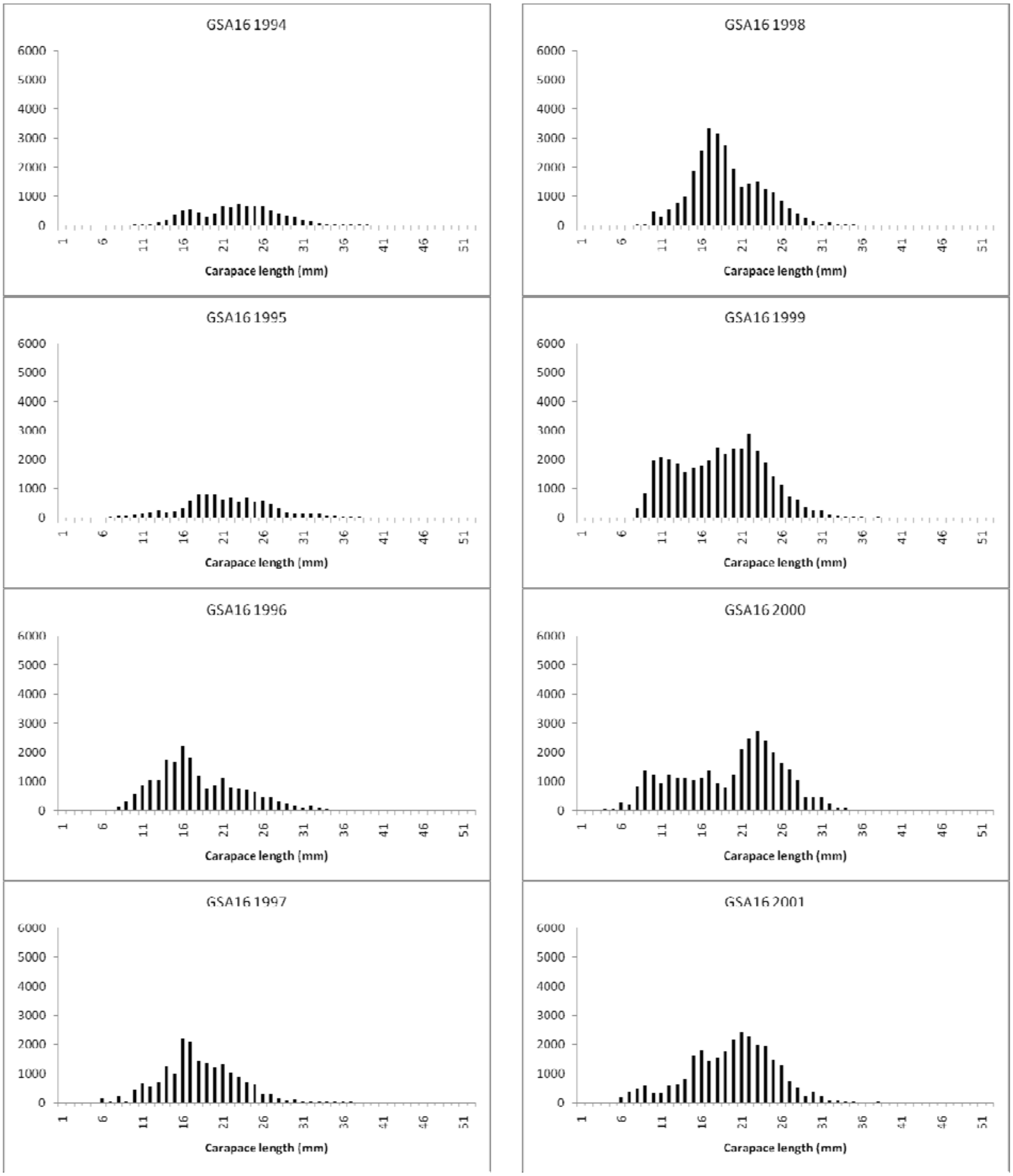


Fig. 5.37.3.1.4.1 Stratified abundance indices by size, 1994-2001.

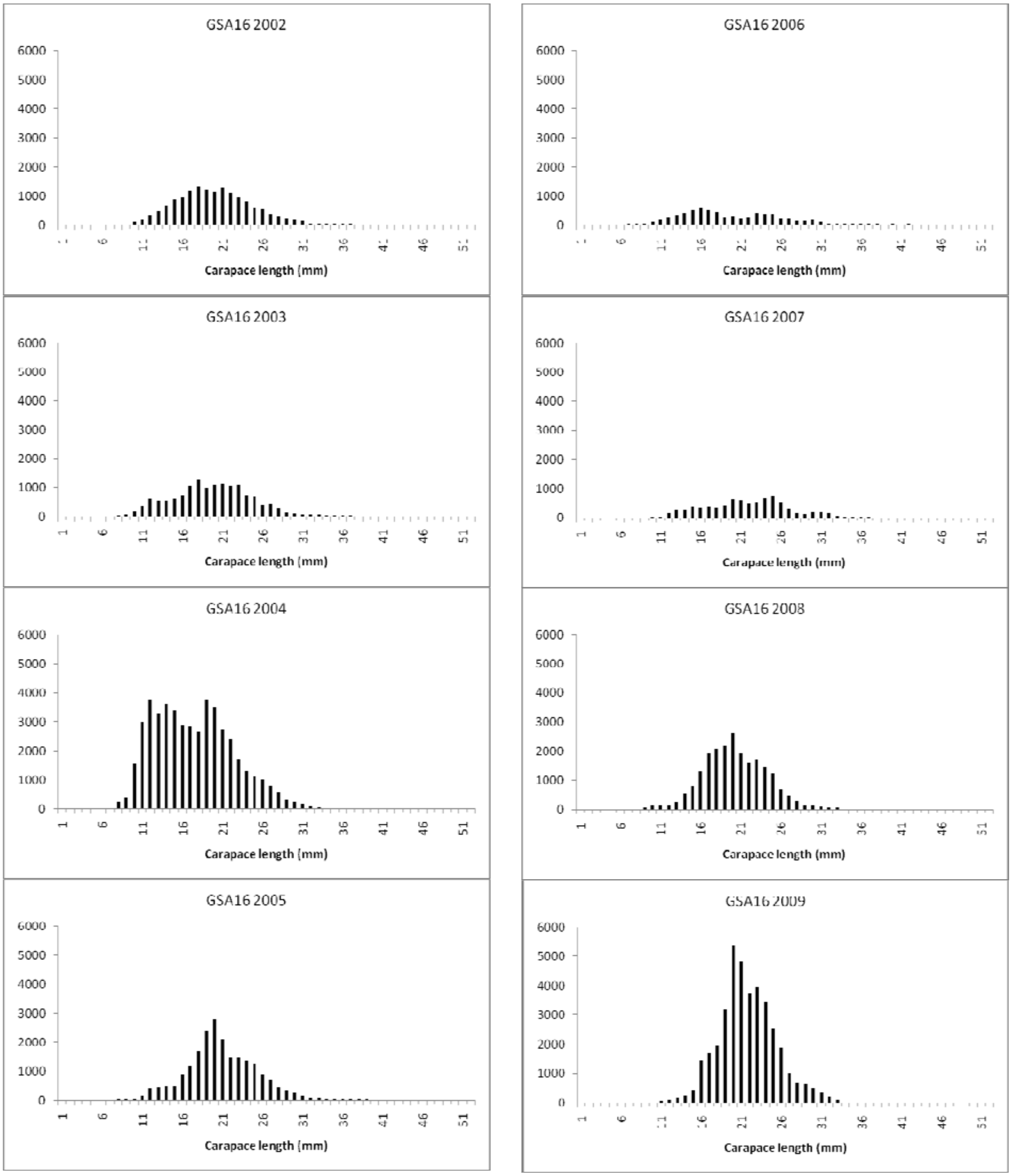


Fig. 5.37.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.37.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.37.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.37.4. Assessment of historic stock parameters

5.37.4.1. Method 1: Trends in LPUE

5.37.4.1.1. Justification

Trends in LPUE may provide insight into trends in stock size. SGMED-10-02 recommends that technological creep should be considered when trends in LPUE are interpreted.

5.37.4.1.2. Input parameters

Landings and effort for the Sicilian trawler fleet operating in GSA 16 were used.

5.37.4.1.3. Results including sensitivity analyses

Fig. 5.37.4.1.3.1 Yearly landings per unit effort of commercial trawling by the Sicilian fleet operating in the Strait of Sicily.

Considering the inconsistency of effort data for larger trawler in 2006, LPUE of 24-40 segment and overall trawlers were not calculated for this year.

On the basis of the available time series, a recovery of LPUE were observed in 2008 (Fig. 5.37.4.1.3.1).

5.37.4.2. Method 2: VIT

5.37.4.2.1. Justification

According to the SGMED 10-02 suggestions, an approach under steady state (pseudocohort) was used, keeping separate the available years (2006, 2007 and 2008), as well as fleet segments (trawlers with 12<LOA<24 m and LOA>24m). Pseudocohort and Y/R analyses as implemented in the package VIT4win were used (Lleonart and Salat 1997, 2000). Data were derived from DCF call for GSA 16.

5.37.4.2.2. *Input parameters*

The parameters used in the analysis are reported in Table 5.37.4.2.2.1. Since the discarded fraction represents less than 1% of landings, no discard data were included in the analysis.

Table 5.37.4.2.2.1. Parameters (combined sex) used for stock assessment trough the VIT approach. The entire catch was analyzed, i.e. potential sex differences were not considered.

Linf	**44.29**	**a**	**0.0033**
K	**0.628**	**b**	**2.4572**
t0	**-0.205**		

Table 5.37.4.2.2.2 Vectors of maturity and mortality by size.

CL (mm)	M	%of mature	CL (mm)	M	%of mature
11	1.89	0.02	26	0.59	0.92
12	1.68	0.06	27	0.56	0.92
13	1.47	0.10	28	0.54	0.93
14	1.34	0.17	29	0.51	0.93
15	1.21	0.30	30	0.50	0.94
16	1.13	0.50	31	0.48	0.95
17	1.04	0.70	32	0.45	0.96
18	0.92	0.82	33	0.44	0.96
19	0.88	0.90	34	0.43	0.97
20	0.83	0.93	35	0.42	0.98
21	0.76	0.93	36	0.41	0.98
22	0.73	0.93	37	0.40	1.00
23	0.71	0.92	38	0.39	1.00
24	0.66	0.92	39	0.38	1.00
25	0.62	0.92	40	0.38	1.00

Table 5.37.4.2.2.3 Absolute numbers by length class of landings by year and fleet segments.

	2006		2007		2008	
CL(mm)	**12_24**	**>24**	**12_24**	**>24**	**12_24**	**>24**
11		219944	108020			
12	2757320	1247748	237781			88112
13	3406184	12339611	1618155			110140
14	4391612	25923620	8869227		30030	477901
15	13957955	46075155	23794053	138530	47930	1636874
16	23585129	71261708	46825135	585622	189548	3284814
17	38638155	71406492	60704078	1870315	2538944	3271624
18	47630021	63856713	68114280	5083381	1968000	5469994
19	55650981	73276614	61765068	10256251	5948761	7231046
20	86618629	77140996	61365864	23615811	9565808	16605508
21	87085667	70609449	47071000	35800164	14677103	22575960
22	64559700	44907942	37662609	37002334	16195107	24526371
23	53583602	32172707	28706591	42843160	19468525	25661302
24	48220392	26043748	23900218	38002862	20752973	24558698
25	41545012	15597256	17441597	34235033	26543267	22045858
26	29987827	9808084	10888050	32101622	20028568	18306841
27	19300311	6596727	5151322	30445559	11732591	14908725
28	9290588	4153322	2054979	24960877	8158662	13034700
29	4623520	3279508	1129102	17020428	8183844	11562949
30	2105999	1973553	553293	16130468	10648144	12150186
31	564574	371581	262230	15080567	11541453	9329119
32	303507	287639	110738	8855811	7128564	6421897
33	181653	123860	77402	6712577	4969229	3344830
34	120000	130000	44689	4692785	2303741	2067225
35	80000	90000		2335037	1623312	938260
36	35965	40466		750968	391248	317319
37				625963	248881	367448
38				350000	112017	174725
39				120000	65505	91996
40				74558		47429
	638224302	658934442	508455482	389690684	205061754	250607849

5.37.4.2.3. Results

Fishing mortality rates (F) by size and fleet segments of deep water pink shrimps in GSA 16 are shown in Fig. 5.37.4.2.3.1.

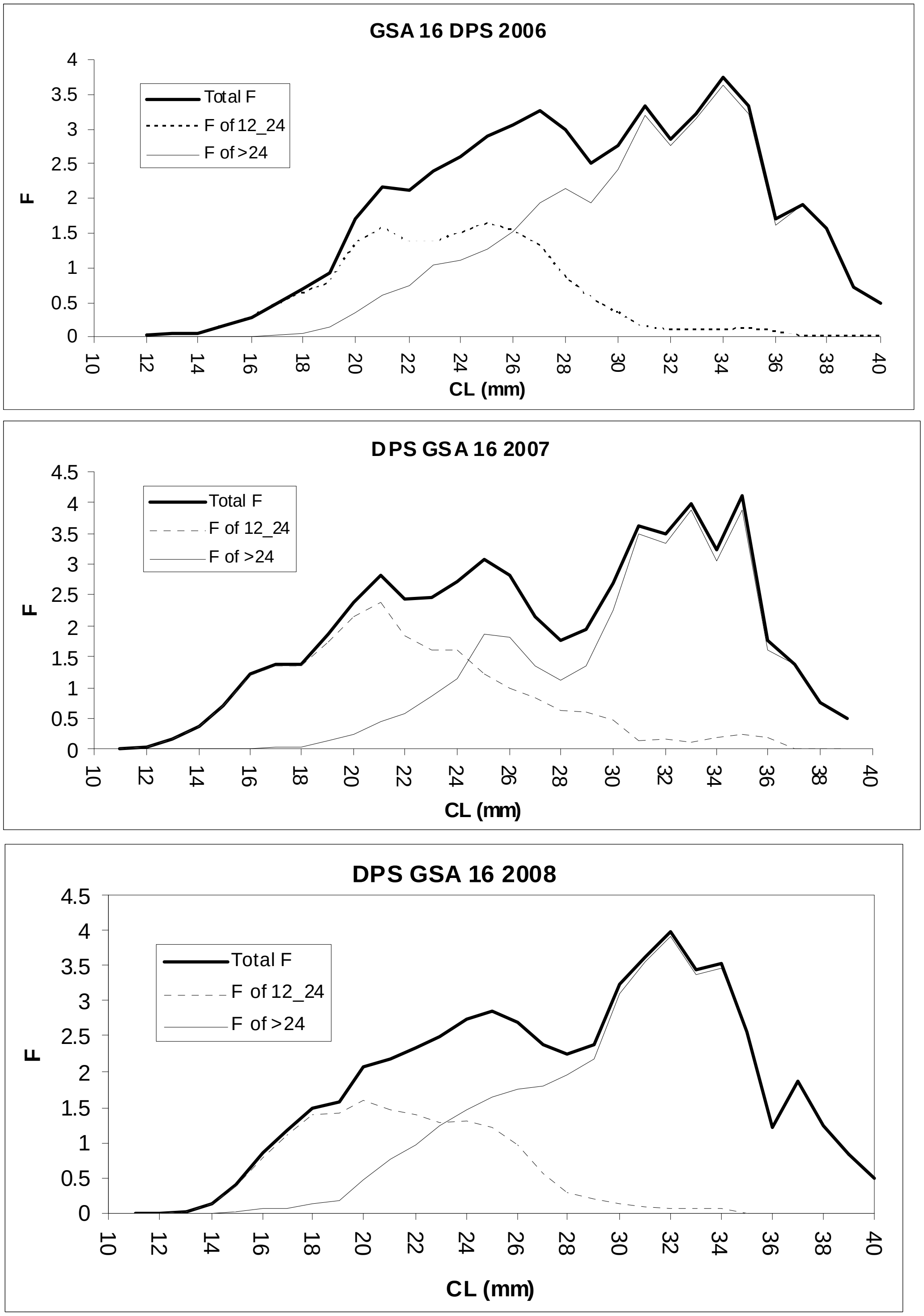


Fig. 5.37.4.2.3.1 Fishing (F) mortalities rates by size and year of deep water shrimps in GSA 16.

The reconstructed yields obtained by applying the VIT package are virtually equal to the observed ones. Absolute recruitment estimation and other main results of VIT, including the current mortality rates, are listed in table 5.37.4.2.3.1.

Table 5.37.4.2.3.1 The main results of the VIT analysis.

Year	2006	2007	2008	Mean
Recostructed yield (t)	8455	5989	5941	6795
Recruitment (ml)	2417	2506	2061	2328
Z	2.48	2.67	2.55	2.57
F	1.87	2.03	1.93	1.94
F 12_24	0.37	0.53	0.43	0.44
F>24	1.51	1.50	1.51	1.51

5.37.5. Long term prediction

5.37.5.1. Method 1: VIT

5.37.5.1.1. Justification

The VIT approach to estimate biomass and yield per recruit analysis has been applied in order to analyse the stock production with increasing exploitation under equilibrium conditions.

5.37.5.1.2. Input parameters

The input parameters have been already reported in section 5.37.4.2.2 (VIT assessment).

5.37.5.1.3. Results

The results of estimating spawning stock biomass as well as biomass and yield per recruit, by varying current fishing mortality through a multiplicative factor for 2006, 2007 and 2008 catches, are reported in Fig. 5.37.5.1.3.1.

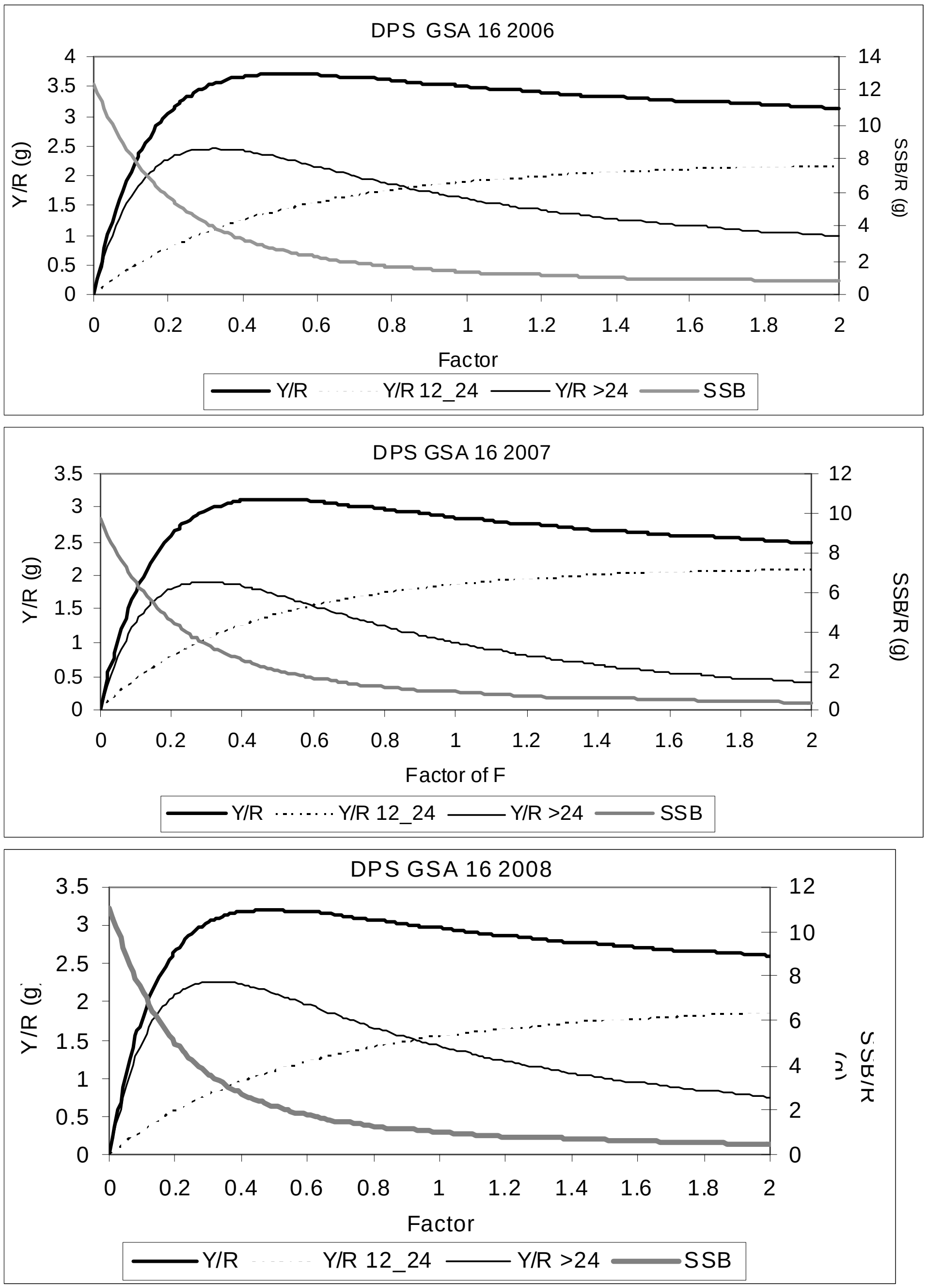


Fig. 5.37.5.1.3.1 Spawning Stock Biomass (SSB) and Yield (Y) per recruit varying current fishing mortality by a multiplicative factor according to the VIT package, 2006-2008.

Assuming no variation in the exploitation pattern, the main results of the Y/R analysis are reported in Tab. 5.37.5.1.3.1.

Tab. 5.37.5.1.3.1 Estimation of yield (Y in g), biomass (B in g) and spawning stock biomass (SSB in g) per recruit (R), varying current fishing mortality by a multiplicative factor (φ).

	Year	Factor	Y/R	B/R	SSB/R	Y/R 12_24	Y/R >24
Null F	2006	0	0	14.247	12.38	0	0
F(0.1) 12_24		0.3	3.491	5.489	4.226	1.034	2.457
Max >24		0.33	3.541	5.237	3.997	1.079	2.462
Max overall)		0.52	3.713	3.641	2.567	1.427	2.286
Current F		1.01	3.498	2.194	1.333	1.889	1.609
Double F		2	3.147	1.448	0.75	2.162	0.985
Null F	2007	0	0	11.384	9.685	0	0
F(0.1) 12_24		0.3	2.961	4.458	3.337	1.052	1.908
Max >24		0.31	2.961	4.458	3.337	1.052	1.908
Max overall)		0.49	3.119	3.064	2.108	1.386	1.733
Current F		1.01	2.856	1.639	0.917	1.856	1
Double F		2	2.486	0.982	0.419	2.079	0.407
Null F	2008	0	0	12.791	11.064	0	0
F(0.1) 12_24		0.28	2.98	4.759	3.62	0.956	2.025
Max >24		0.3	3.004	4.631	3.504	0.979	2.025
Max overall)		0.47	3.154	3.136	2.17	1.308	1.847
Current F		1.01	2.881	1.625	0.896	1.815	1.066
Double F		2	2.536	1.018	0.435	2.039	0.497

According to the VIT steady state VPA, a state of overfishing for all three years was clearly detected. Maintaining the current fishing pattern, a reduction of current fishing mortality of about 70% is advisable to reach $F_{0.1}$ for smaller trawlers, and F_{max} for large trawlers. There appears no significant loss in Y/R attributable to the move from F_c to $F_{0.1}$. It is worth to note that data of 2009 were not available and that an improvement of fishing pattern, with some effects on the current stock status, might be expected after implementing the new mesh size in June 2010.

5.37.5.2. Method 1: YIELD

5.37.5.2.1. Justification

Availability of biological parameter estimates with their uncertainty and the length at fully capture, allows a quantitative simulation or the likely changes in Y, B and SSB per recruit in function of fishing mortality (F) with the Yield package. It is also possible to estimate the probability distribution of the main Biological Reference Point (F_{max}, $F_{0.1}$ and $F_{spr=0.3}$, and the corresponding Yield per Recruit) in order to assess the stock status.

5.37.5.2.2. Input parameters

The current fishing mortality was estimated by subtracting an estimate of the natural mortality from the current total mortality rate (Z). Total mortality was estimated by Beverton & Holt Z estimator on trawl surveys data on MEDITS (2006-2007 and 2008-2009) length frequency distributions using the LFDA package (Kirkwood et. al 2001).

Growth and length-weight relationship parameters were the same as those used for the VIT analysis described above. Natural mortality was 0.85 and length at 50% maturity, derived by the combined sex vector was 16 mm CL. Minimum length at fully capture for combined sex was 17 mm CL. All the linear parameters were expressed as TL (cm). Conversions were subsequently made by using the relationship reported by Crosnier et al. (1970) for combined sex: TL (mm) = 3.646+4.436 CL (mm). A guess estimate of uncertainty in terms of coefficient of variation (CV=0.2) was added to each parameter.

A spawning stock-recruitment relationship was not used. Variables were estimated for 1 million young shrimp nominal recruitment. The recruitment variability among years was estimated as CV=0.6 from recruit indices obtained in trawl surveys.

The length frequency distributions of two subsequent years from the MEDITS trawl surveys (1994+1995, 1996+1998 and so on) were added in order to match the steady state assumption required by the Beverton and Holt Z estimator. For each couple of years an estimation of F was obtained from Z – M.

5.37.5.2.3. Results

Estimation of Y and SSB per recruit is shown in Fig 5.37.5.2.3.1.

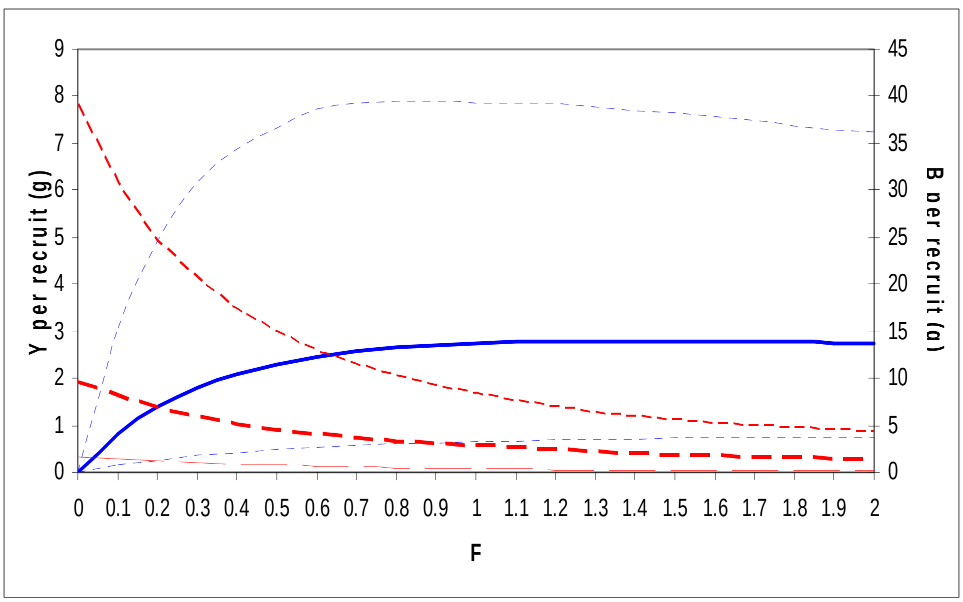


Fig. 5.37.5.2.3.1 Median of yield and spawning stock biomass per recruit, as well as corresponding uncertainty of deep water pink shrimp in the Strait of Sicily according to the Yield Package.

Searching for biological reference points (BRP) through 2000 simulation produced the median values reported in Fig. 5.37.5.2.3.2. Y/R_{max} and F_{max} should be considered as Limit Reference Points (LRP), whereas Y/R 0.1, F0.1, $Y/R_{SPR\_0.30}$ and $F_{SPR\_0.30}$ should be considered as target reference points (TRP).

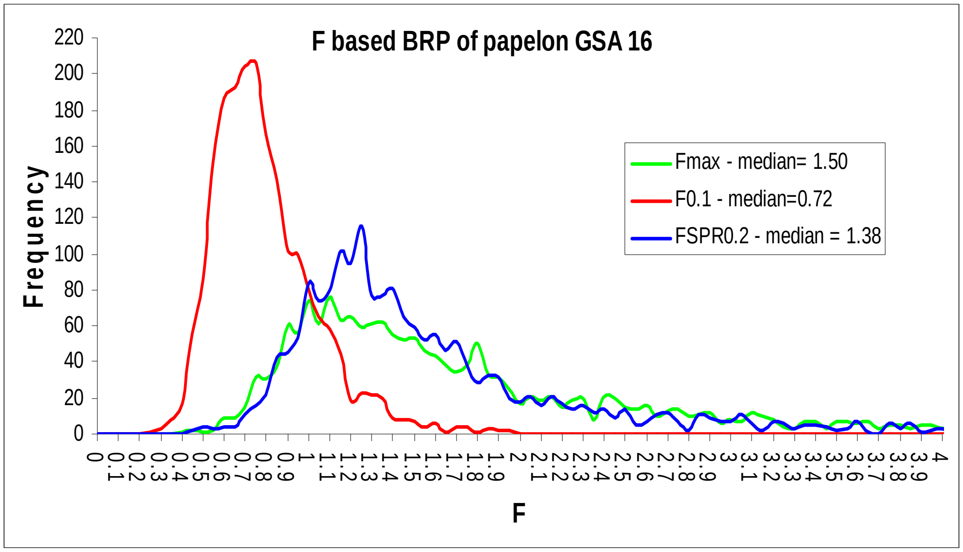


Fig. 5.37.5.2.3.2. Probability distribution and median values of yield (g) per recruit and fishing mortality based BRP of deep water pink shrimp in the Strait of Sicily according to the Yield package.

The mean fishing mortality over the entire time series was 1.52 ± 0.39. The detailed estimates for each couple of years are shown in Fig 5.37.5.2.3.3.

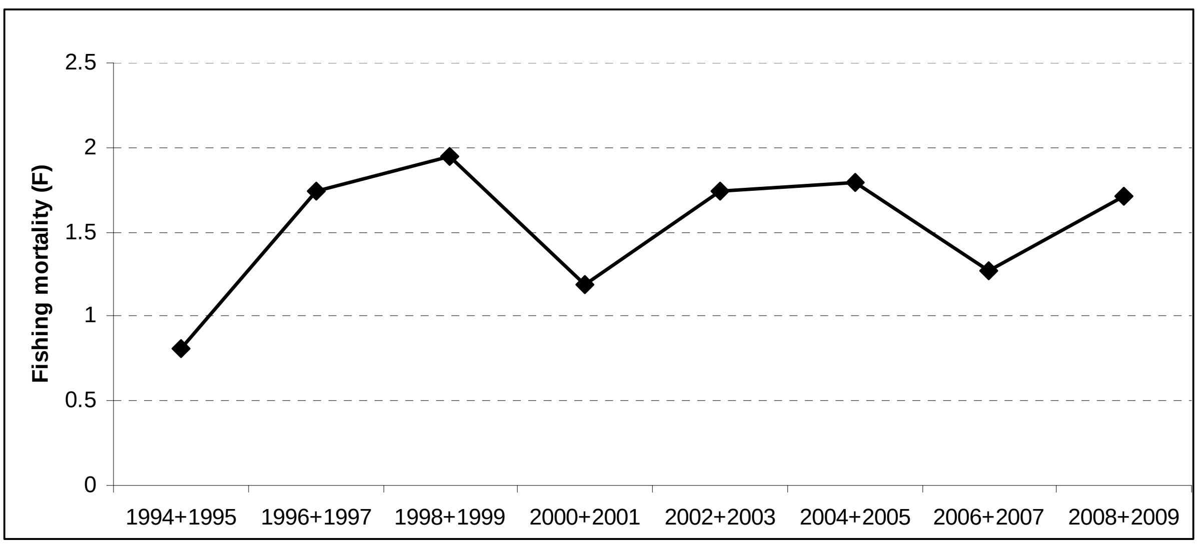


Fig. 5.37.5.2.3.3 Fishing mortality rates estimated according to Beverton and Holt Z estimator. For each couple of years an estimation of F was obtained as Z – M. The mean F over the time series is 1.52 ± 0.39.

Considering the analysis based on Yield package and the Beverton and Holt estimator mean values (2006-2009), a state of overfishing which is less severe than that detected by the VIT approach was found. The F_c (1.49) was very close to the F_{max} (1.50) and higher than the $F_{0.1}$ (0.72).

5.37.6. Data quality

In terms of data quality and availability, SGMED 10-02 noted that data from GSA 15 was never submitted and thus could not be included in the assessments. Whilst data from commercial catches declared in GSA 16 are representative for the entire area, the lack of scientific survey data from GSA 15 did impact the overall quality of the assessment; the Central Mediterranean hake population is distributed throughout both GSA 15 and GSA 16.

SGMED 10-02 further noted the absence of GSA 16 2009 landings and effort data, which meant assessments based on commercial catches could only be carried out for years 2006, 2007 and 2008. Finally, an error in the GSA 16 effort data in terms of KW * Days was noted for otter board trawlers measuring > 24m in length in 2006.

In order to increase the overall quality of the assessments, an analysis including catch of other countries is required. An pilot exercise on LCA, based on 2007 and 2008 landings data from Sicily, Tunisia and Malta was carried out in Malta in 2009 within the framework of the FAO regional project MEDSUDMED (Medsudmed, 2009).

5.37.7. Scientific advice

5.37.7.1. Short term considerations

5.37.7.1.1. State of the spawning stock size

In the absence of proposed and agreed precautionary management reference points SGMED is unable to fully evaluate the state of the SSB. According to VIT analysis, absolute estimations of SSB (combined sex) in the 2006-2008 was 3223 t in 2006, 1920 t in 2007 and 1580 t in 2008. Recent MEDITS indices in 2009 indicate a significant stock recovery in both GSAs 15 and 16.

5.37.7.1.2. State of recruitment

The estimates of absolute recruitment in millions of individuals (11-12 mm CL) from VIT analysis in 2006-2008 were 2,417 in 2006, 2,098 in 2007 and 2,061 in 2008. The time series of recruitment indices from trawl surveys (individuals smaller than 16 mm CL) showed a peak in 2004 (1,802 recruits per km^2) in the spring trawl surveys, and in 2005 (1,286 recruits per km^2) for the autumn surveys. The mean indices over the time series were 341 ± 463 in spring and 258 ± 306 in autumn. The spring indices in the last three years (2007-2009) were lower than the mean, whereas the only value available for the autumn series (2008) was higher than the corresponding mean.

5.37.7.1.3. State of exploitation

SGMED proposes $F_{0.1}$ ranging between 0.62 (median of VIT analyses) and 0.72 (Yield and Beverton and Holt estimator) as limit management reference point for exploitation consistent with high long term yield. The stock of deep water pink shrimp in the Northern sector of the Strait of Sicily is considered overfished in 2006-2008 as the current fishing mortality is higher than $F_{0.1}$ and F_{max} according to the VIT analyses and higher than $F_{0.1}$ and close to F_{max} according to the trawl surveys data. SGMED recommends an overall reduction ranging between 50 and 70% of the current fishing mortality, which would be necessary in order to achieve the proposed management reference point.

The working group was informed that the Italian government is adopting a management plan in which a reduction of fishing capacity of 25% for trawlers larger than 18 m LOA operating in the Strait of Sicily is planned until 2013. It is worth to note that an improvement of fishing pattern, with some effects on the current stock status, should also be expected after implementing the new mesh size after June 2010. SGMED supports the rapid adoption and the implementation of the Italian management plan. This should continuously reduce current F towards F_{01}, both through consistent effort reductions and improving current exploitation patterns. A trawling ban on the main pink shrimp nursery sites in the Strait of Sicily is in addition recommended.

5.38. Stock assessment of pink shrimp in GSA 18

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.38.1. Stock identification and biological features

5.38.1.1. Stock Identification

The stock of pink shrimp was assumed in the boundaries of the whole GSA18, lacking specific information on stock identification and given the preliminary indications agreed upon by SGMED-09-01. The deep-water rose shrimp inhabits only muddy sediments, at depths over 130 m (Karlovac, 1949) and in the southern Adriatic it is distributed mostly between 30 and 600 m depth although it is more abundant between 200 and 400 m depth (Pastorelli *et al*., 1996). Within the southern Adriatic, the eastern part is characterised by the higher occurrence and abundance of the species, given the characteristics of the water masses (warmer and saltier) and the lower fishing pressure (Abellò *et al*., 2002; Mannini et al., 2004) and particularly of the juvenile component of the population (Ungaro *et al*., 2006). Spawning time is considered extended almost all the year round, as for other Mediterranean areas (Relini, 1999) and sex ratio as estimated from trawl-survey data is approximately 0.45. The abundance of this shrimp is steadily growing in the last decade (Ungaro *et al*., 2006) that is one of the target species of the central and southern Adriatic multispecies trawl catches. In some fisheries the pink shrimp can represent a percentage between 5 and 10% of the total catches (Medits 2007).

5.38.1.2. Growth

P. longirostris can grow up to 16 cm (males) and 19 cm (females) in total length. However, males are usually 8 to 14 cm long and females from 12 to 16 cm long. Larger specimens are caught mainly in deeper waters. During the expedition “Hvar”, the largest specimen caught was a 17 cm long female (Karlovac, 1949). The growth rate differs between the sexes. Size distribution and growth parameters indicate a life cycle of 3-4 years (Froglia, 1982).

Estimates of growth parameters were achieved made with data collected within the DCR framework using the analysis of length frequency distributions. The following von Bertalanffy parameters were estimated by sex: females CL_∞=44.0 mm; K=0.628; t_0= -0.20; males: CL_∞=39 mm; K=0.69; t_0= -0.20.

Parameters of the length-weight relationship reported in literature for carapace length expressed in mm and sex combined (Marano *et al*., 1998) are a=0.0034, b=2.4364. The parameters estimated within the DCR here for sex combined and carapace length expressed in cm were: a=1.0692, b=2.23.

5.38.1.3. Maturity

In the Mediterranean Sea, both sexes of *P. longirostris* reach maturity in the first year of life (Froglia, 1982). After being spawned, the planctonic larval phases (nauplius, zoea and mysis) develop; the postlarva, similar to adults, reaches the sandy-muddy bottoms on the continental shelf and begins the bentho-pelagic cycle (Heldt, 1938). According to the data obtained in the DCR, the proportion of mature females (specimens belonging to the maturity stage 2 onwards) by length class is reported in the table below together with the maturity ogive estimated by a maximum likelihood procedure which indicates a $L_{m50\%}$ of about 1.83 cm (±0.01 cm) and a maturity range (MR) equal to 0.24 cm, ($L_{m75\%}$-$L_{m25\%}$ ±0.013 cm).

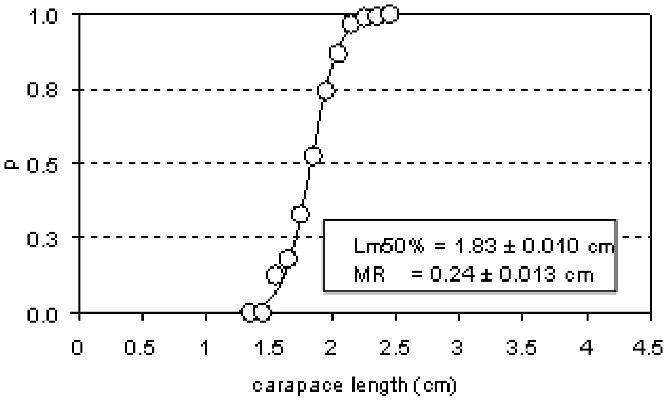


Fig. 5.38.1.3.1 Maturity ogive and proportions of mature female of pink shrimp in the GSA 18 (MR indicates the difference $L_{m75\%}$-$L_{m25\%}$).

The sex ratio evidenced the prevalence of males in the size class from 1.6 to 1.8 cm and from 2.3 to 2.5 cm, while from 2.7 cm onwards the proportion of females was dominant.

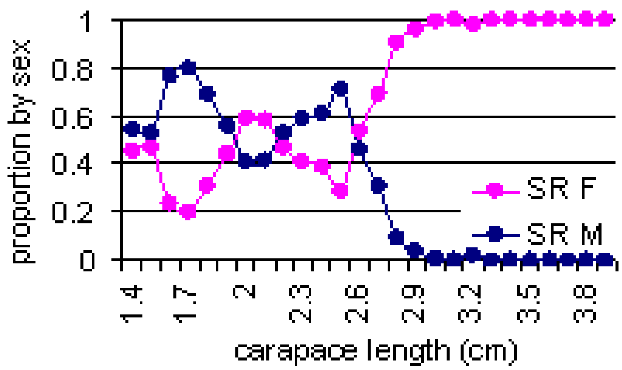


Fig. 5.38.1.3.2 Sex ratio at length of pink shrimp in the GSA 18.

5.38.2. Fisheries

5.38.2.1. General description of fisheries

Pink shrimp is only targeted by trawlers and fishing grounds are located along the coasts of the whole GSA. Catches from trawlers are from a depth range between 50-60 and 500 m and pink shrimp may co-occurs with other important commercial species as *M. merluccius*, *Illex coindetii*, *Eledone cirrhosa*, *Lophius* spp., *Lepidorhombus boscii*, *N. norvegicus*.

5.38.2.2. Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures, like the number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of the fleet, the Italian fishing licenses have been fixed since the late 1980s. After 2000, in agreement with the European Common Fisheries Policy, a gradual decreasing of the fleet capacity is implemented. Two closed areas were also established in 2004 along the mainland, in front of Bari and in the vicinity of Tremiti MPA on the northernmost part of the GSA. Other management regulations are mesh size, minimum landing sizes and the minimum distance (or depth) from the coastline (EC reg. 1967/2006). In the GSA 18 the fishing ban has been almost always mandatory since 1988 for a period of 30-45 days, generally during late July-early September.

5.38.2.3. Catches

5.38.2.3.1. Landings

Available landing data are from DCR regulations. SGMED-10-02 received Italian landings data for GSA 18 by major fishing gears which are listed in Tab. 5.38.2.3.1.1. Landings of pink shrimp were decreasing from 1,857 t in 2004 to 766 t in 2008.

Tab. 5.38.2.3.1.1. Annual landings (t) by major gear type, 2004-2008. No data were provided for 2009 by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	18	ITA								9			
DPS	18	ITA	GNS	DEMSP				7					
DPS	18	ITA	GTR	DEMSP				1					
DPS	18	ITA	LLS	DEMF				1					
DPS	18	ITA	OTB	DEMSP				55	9	370	128	586	
DPS	18	ITA	OTB	DWSP								19	
DPS	18	ITA	OTB	MDDWSP				1793	1173	1095	735	161	
DPS	18	ITA	PTM	SPF				0					
Sum								1857	1182	1474	863	766	

5.38.2.3.2. Discards

No information was documented during SGMED-10-02.

5.38.2.3.3. Fishing effort

The trends in fishing effort by year and major gear type is listed in Tab. 5.38.2.3.3.1 in terms of kW*days.

Tab. 5.38.2.3.3.1 Trend in fishing effort (kW*days) of trawlers (DTS-OTB) in the GSA 18, 2004-2008.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
18	ITA				VL0006						653	
18	ITA				VL1218				18973			
18	ITA	DRB	MOL		VL1218		31755	15206	60312	29038	24106	
18	ITA	GNS	DEMSP		VL0006				0	0	0	
18	ITA	GNS	DEMSP		VL0612		79455	107014	73603	59052	76376	
18	ITA	GNS	DEMSP		VL1218				11360			
18	ITA	GTR	DEMSP		VL0006				0	767	3639	
18	ITA	GTR	DEMSP		VL0612		9276	16931	947		48849	
18	ITA	LHP-LHM	CEP		VL0006						1115	
18	ITA	LHP-LHM	CEP		VL0612				0			
18	ITA	LLD	LPF		VL0006						1453	
18	ITA	LLD	LPF		VL0612				0		1686	
18	ITA	LLD	LPF		VL1218			4999		3454		
18	ITA	LLS	DEMF		VL0006				1031	0	731	
18	ITA	LLS	DEMF		VL0612		2168	8862	8103	21686	24959	
18	ITA	LLS	DEMF		VL1218			4999	7077	43626	84915	
18	ITA	OTB	DEMSP		VL0612		31970	31096	30666	13651	27993	
18	ITA	OTB	DEMSP		VL1218				566531		485808	
18	ITA	OTB	DEMSP		VL1824						182427	
18	ITA	OTB	DEMSP		VL2440		36432				122656	
18	ITA	OTB	MDDWSP		VL0612		1409					
18	ITA	OTB	MDDWSP		VL1218		426469	539707		486560	49978	
18	ITA	OTB	MDDWSP		VL1824		390285	349132	553919	455935	44323	
18	ITA	OTB	MDDWSP		VL2440		339413	244695	123388	144908	4025	
18	ITA	PS	SPF		VL2440					27636	10183	
18	ITA	PTM	SPF		VL2440		74992	112819	141218	191256	128292	

5.38.3. Scientific surveys

5.38.3.1. Medits

5.38.3.1.1. Methods

Trawl surveys were carried out applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area (Bertrand et al., 2002). The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed.

Based on the DCR data call, abundance and biomass indices were calculated. In GSA 18 the following number of hauls was reported per depth stratum (Tab. 5.38.3.1.1.1).

Tab. 5.38.3.1.1.1. Number of hauls per year and depth stratum in GSA 18, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA18_010-050	14	15	15	14	14	14	14	15	13	13	12	9	10	11	10	10
GSA18_050-100	14	14	14	15	15	15	15	14	21	21	23	16	15	15	14	13
GSA18_100-200	24	23	23	23	23	23	23	23	34	31	32	25	25	23	22	25
GSA18_200-500	10	10	10	10	10	10	10	10	15	15	16	10	10	9	8	11
GSA18_500-800	10	10	10	10	10	10	10	10	14	14	14	7	7	7	5	6

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.38.3.1.2. Geographical distribution patterns

The geographical distribution pattern of pink shrimp in the GSA 18 has been studied using trawl-survey data and geostatistical methods. In these studies the abundance indices of recruits were analysed. Results highlighted that areas localised in the Gulf of Manfredonia and between Monopoli and Brindisi coasts within 200 m depth are mainly characterised by higher concentration of pink shrimp recruits reaching 2000 individuals/km^2 in 2000-2001. A peak of 5000 individuals/km^2 was observed in the southernmost location (border between GSA 18 and 19) off Capo S. Maria di Leuca.

Maps of the pink shrimp nursery obtained applying the indicator kriging techniques are reported below.

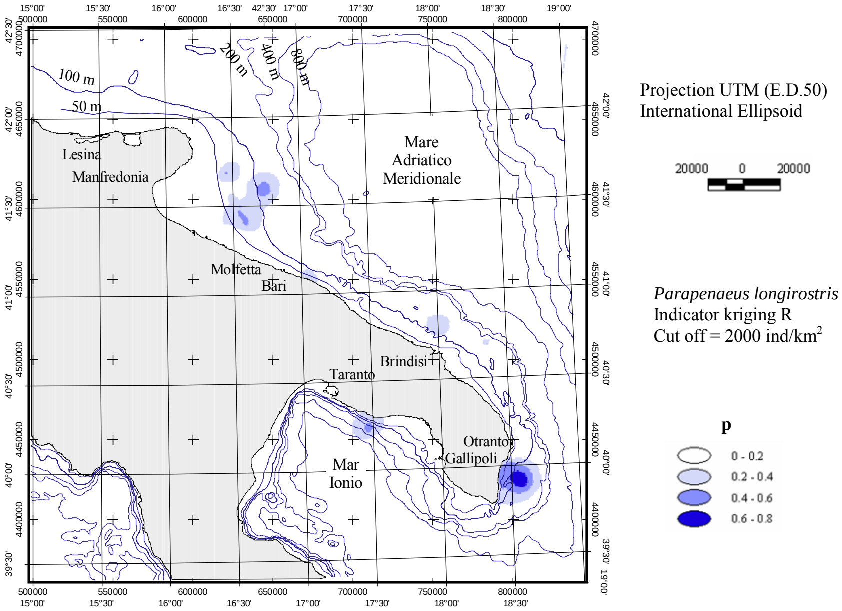


Fig. 5.38.3.1.2.1 Geographical distribution patters as derived from MEDITS.

5.38.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the pink shrimp in GSA 18 was derived from the international survey Medits. Figure 5.38.3.1.3.1 displays the estimated trend of pink shrimp abundance and biomass in GSA 18. Considering only the period from 2001 to 2009, indices show an increasing trend until 2005 and a sharp decline until 2007. Thereafter, the indices remained low.

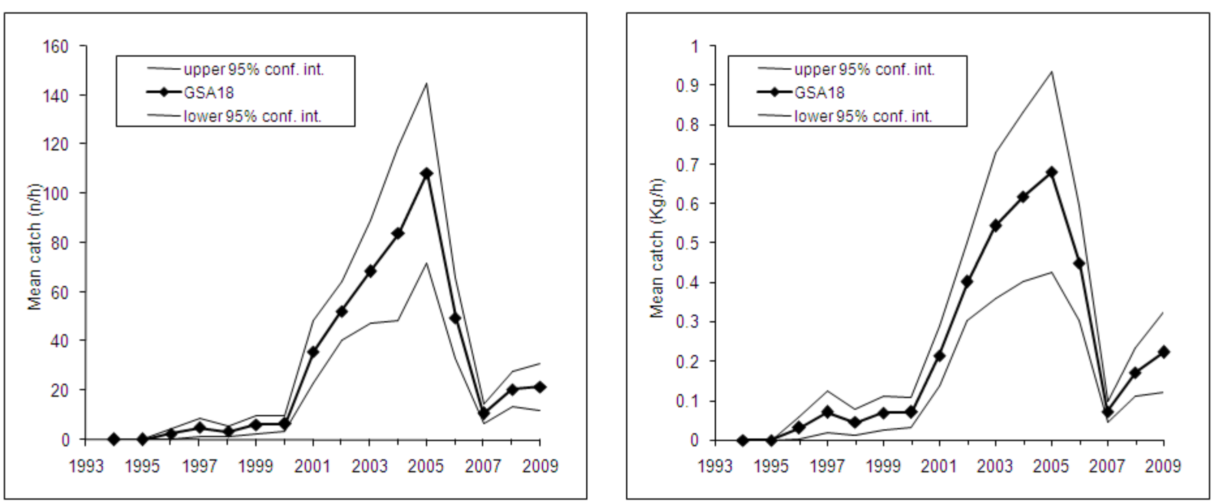


Fig. 5.38.3.1.3.1 Abundance and biomass indices of pink shrimp in GSA 18.

The Medits 2007 report highlighted some changes in the abundance of demersal resources from 1996 to 2006. They mostly refer to the general increase of the species characterised by short life span such as cephalopods and crustaceans (i.e. *Parapenaeus longirostris*) and the decrease of some gadiforms fish such as

Micromesistius poutassou and *Trisopterus minutus*. The report stated that changes could be influenced by both the fishery pressure on large- sized and long-lived species (Jukic-Peladic *et al.*, 2001) and the effects of the environmental conditions (i.e. increase of bottom temperature).

5.38.3.1.4. Trends in abundance by length or age

The following Fig. 5.38.3.1.4.1 and 2 display the stratified abundance indices of GSA 18 in 1996-2003 and 2004-2009.

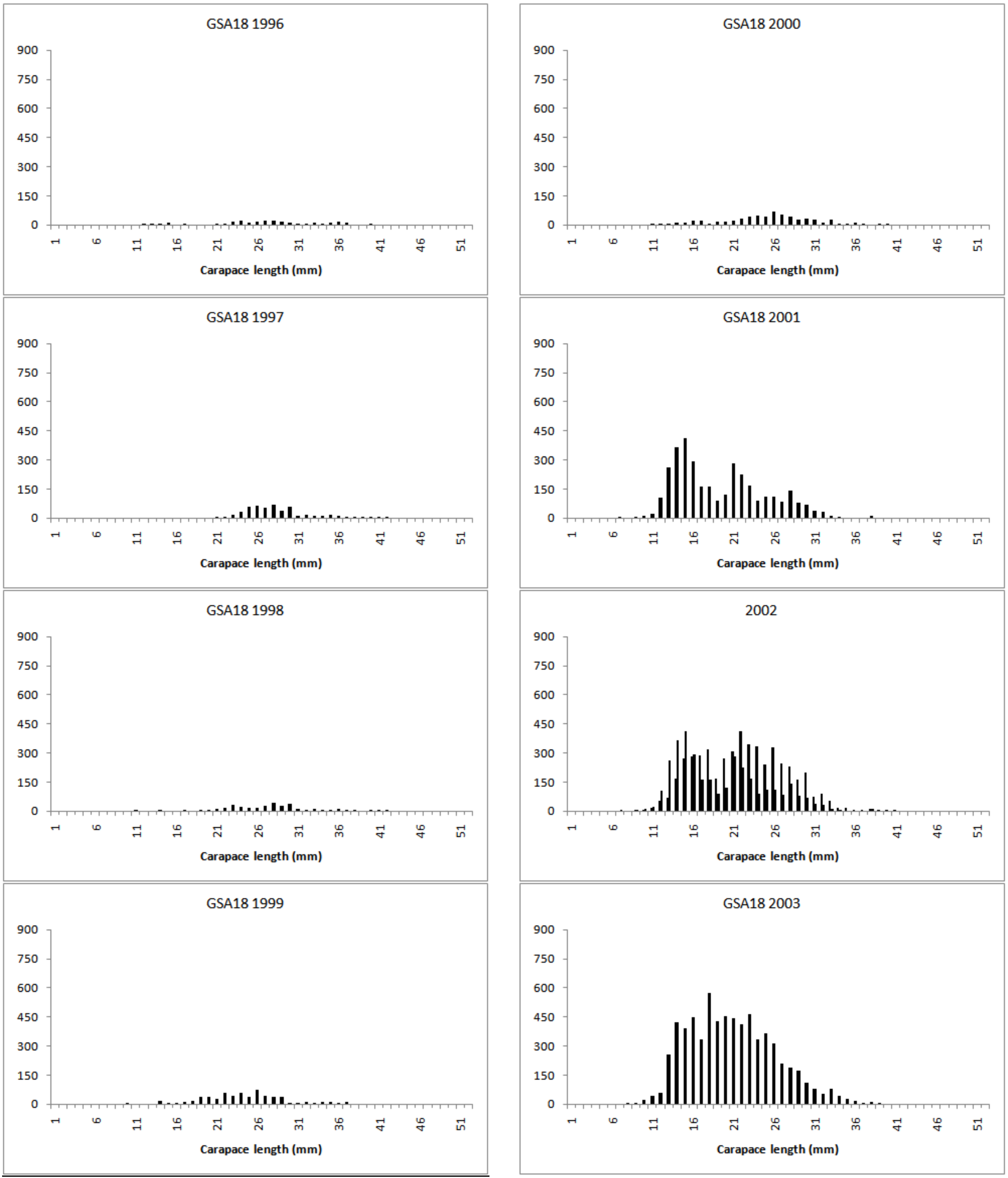


Fig. 5.38.3.1.4.1 Stratified abundance indices by size, 1996-2003.

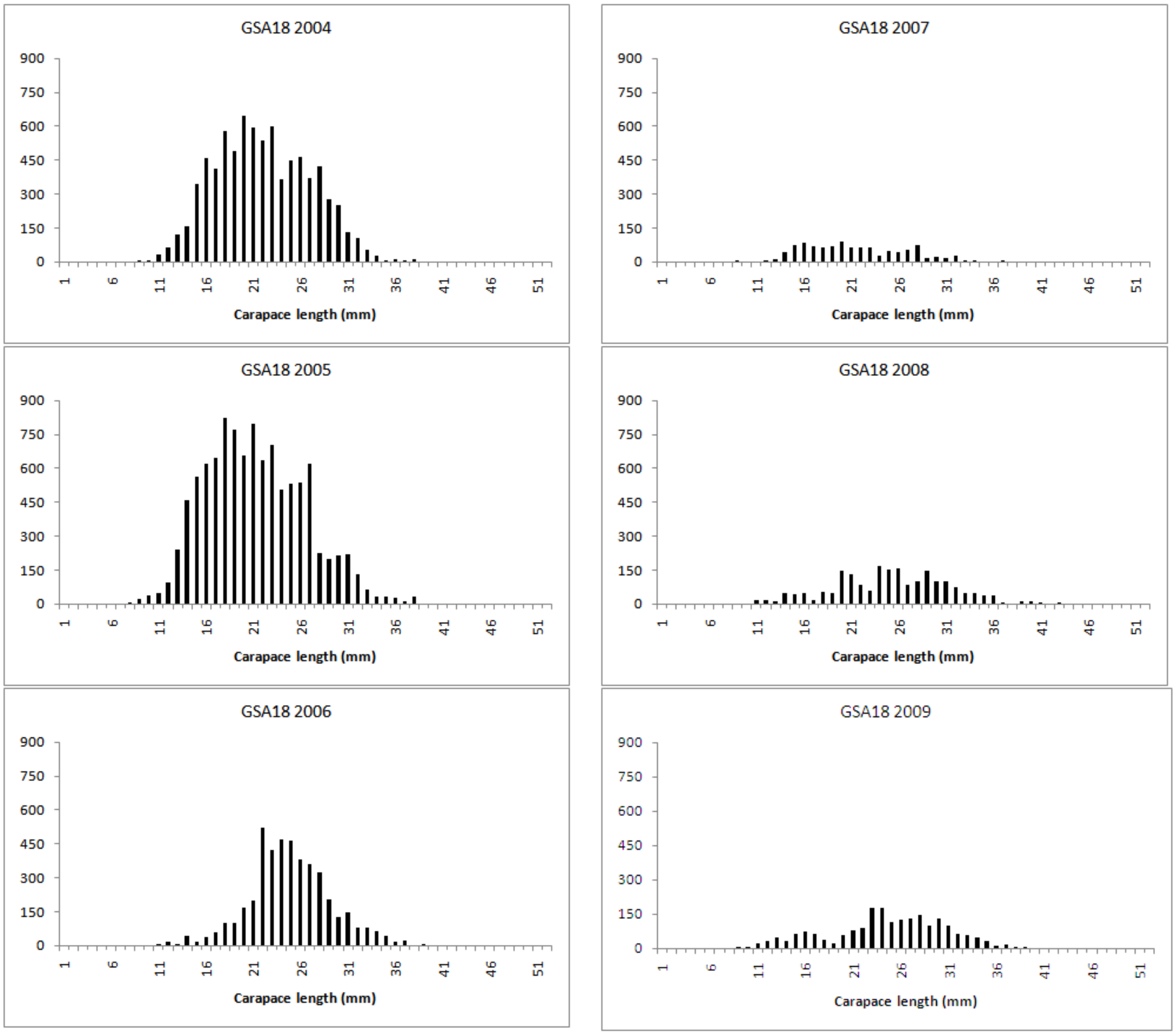


Fig. 5.38.3.1.4.2 Stratified abundance indices by size, 2004-2009.

5.38.3.1.5. *Trends in growth*

No analyses were conducted during SGMED-10-02.

5.38.3.1.6. *Trends in maturity*

No analyses were conducted during SGMED-10-02.

5.38.4. *Assessment of historic stock parameters*

SGMED-10-02 did not undertake any analytical assessment.

5.38.5. *Long term prediction*

5.38.5.1. Justification

No forecast analyses were conducted.

5.38.6. Scientific advice

5.38.6.1. Short term considerations

5.38.6.1.1. State of the spawning stock size

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the SSB. Survey results indicate the recent stock size being low.

5.38.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of recruitment in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.38.6.1.3. State of exploitation

In the absence of proposed and agreed management reference points consistent with high long term yields, SGMED-10-02 is unable to fully evaluate the state of exploitation of the stock and provide scientific advice.

5.39. Stock assessment of pink shrimp in GSA 19

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.39.1. Stock identification and biological features

5.39.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.39.1.2. Growth

No information was documented during SGMED-10-02.

5.39.1.3. Maturity

No information was documented during SGMED-10-02.

5.39.2. Fisheries

5.39.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.39.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.39.2.3. Catches

5.39.2.3.1. Landings

Tab. 5.39.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. In 2007 landings droped by about 50 % compared with earlier years and remained low in 2008. The landings were mainly taken by demersal otter trawls.

Tab. 5.39.2.3.1.1 Annual landings (t) by fishing technique in GSA 19, 2004-2008. No data were submitted by the Italian authorities for 2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
DPS	19	ITA						0	0				
DPS	19	ITA	FPO	DEMSP				15					
DPS	19	ITA	GNS	DEMSP				7					
DPS	19	ITA	LLS	DEMF				9					
DPS	19	ITA	OTB	DEMSP				232	193	242	12	187	
DPS	19	ITA	OTB	DWSP						73	54	67	
DPS	19	ITA	OTB	MDDWSP				938	1050	930	542	531	
DPS	19	ITA	PS	LPF					0				
DPS	19	ITA	PS	SPF					1				
DPS	19	ITA	PTM	SPF						0			
DPS	19	ITA	SB-SV	DEMSP				0	0				
Sum								1201	1244	1245	608	785	

5.39.2.3.2. Discards

4 t of discards in 2006 was reported to SGMED-10-02 through the DCR data call in 2009.

5.39.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.39.2.3.3.1.

Tab. 5.39.2.3.3.1 Trends in annual fishing effort by fishing technique deployed in GSA 19, 2004-2008. No data were reported by the Italian authorities for 2009.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
19	ITA				VL0006				0	1589	1289	
19	ITA				VL0612		43727	21997	57851	74979	39123	
19	ITA				VL1218		9424	43715	40060	28934	51895	
19	ITA	FPO	DEMSP		VL0612		25169	2690	3229	4066	4330	
19	ITA	FPO	DEMSP		VL1218		8894				52399	
19	ITA	GND	SPF		VL0006				0	0		
19	ITA	GND	SPF		VL0612		60866		4327	14947	13293	
19	ITA	GND	SPF		VL1218				6437	33090		
19	ITA	GNS	DEMSP		VL0006				0	2317	2514	
19	ITA	GNS	DEMSP		VL0612		42380	52151	52916	116463	56469	
19	ITA	GNS	DEMSP		VL1218		19276	5898	8441		3077	
19	ITA	GTR	DEMSP		VL0006				1576	0	3994	
19	ITA	GTR	DEMSP		VL0612		93233	21618	28909	49607	73983	
19	ITA	GTR	DEMSP		VL1218		37514		9694	22498	33993	
19	ITA	LHP-LHM	CEP		VL0612		0	0			901	
19	ITA	LLD	LPF		VL0006				0	0		
19	ITA	LLD	LPF		VL0612		21059	2262			1613	
19	ITA	LLD	LPF		VL1218		24556	11063		49548	86997	
19	ITA	LLD	LPF		VL1824		130836	29278	87254	162415	221621	
19	ITA	LLS	DEMF		VL0006				0	335	281	
19	ITA	LLS	DEMF		VL0612		32056	17304	941	31232	31930	
19	ITA	LLS	DEMF		VL1218		6788	25928	12992	30438	38940	
19	ITA	LLS	DEMF		VL1824		9101					
19	ITA	LTL	LPF		VL0612				2903			
19	ITA	OTB	DEMSP		VL1218		20694	128112			171458	
19	ITA	OTB	DEMSP		VL1824		45169				18603	
19	ITA	OTB	DWSP		VL1218					57896		
19	ITA	OTB	MDDWSP		VL1218		246735	207953	386565	396114	254049	
19	ITA	OTB	MDDWSP		VL1824		24687	97647	28684	44800	37335	
19	ITA	PS	LPF		VL1218				5610			
19	ITA	PS	SPF		VL0612			28041			6985	
19	ITA	PS	SPF		VL1218		94936		9833	49469	43538	
19	ITA	SB-SV	DEMSP		VL0612		17636					
19	ITA	SB-SV	DEMSP		VL1218		7479		25107		2220	
19	ITA	SB-SV	DEMSP		VL1824		33305					

5.39.3. Scientific surveys

5.39.3.1. Medits

5.39.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 19 the following number of hauls was reported per depth stratum (s. Tab. 5.39.3.1.1.1).

Tab. 5.39.3.1.1.1. Number of hauls per year and depth stratum in GSA 19, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA19_010-050	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9
GSA19_050-100	7	8	8	8	8	8	8	8	8	8	8	8	8	9	8	8
GSA19_100-200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	10
GSA19_200-500	16	15	15	15	15	15	15	15	21	21	14	15	14	14	14	14
GSA19_500-800	31	32	32	32	32	32	32	32	29	29	29	28	29	29	29	30

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA

5.39.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.39.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the pink shrimp in GSA 19 was derived from the international survey Medits. Figure 5.39.3.1.3.1 displays the estimated trend in pink shrimp abundance and biomass in GSA 19.

The estimated abundance and biomass varied without a clear trend. The abundance and biomass indices appear increasing since 2002 with the maximum observed in 2009.

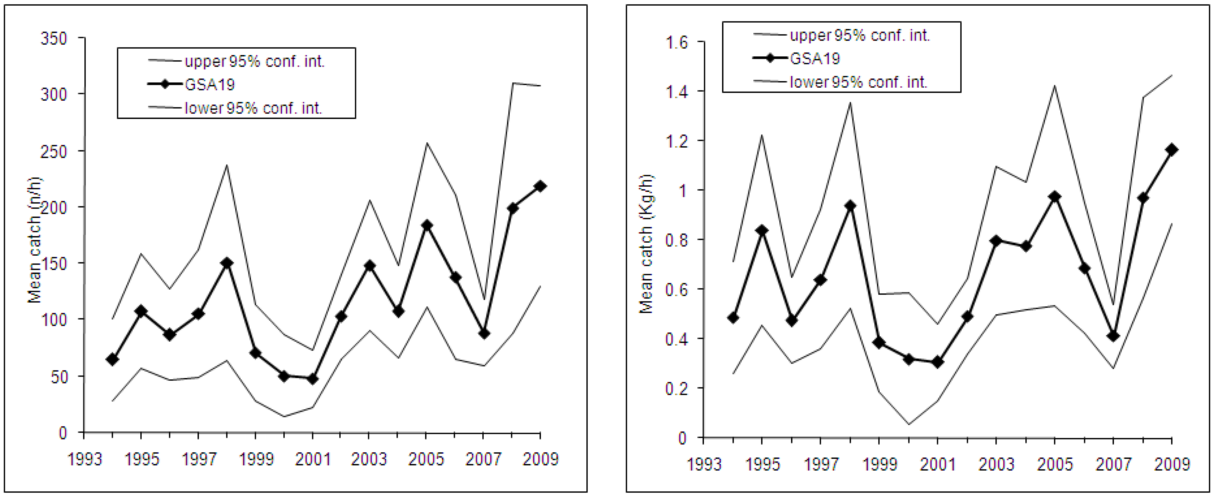


Fig. 5.39.3.1.3.1 Abundance and biomass indices of pink shrimp in GSA 19.

5.39.3.1.4. Trends in abundance by length or age

The following Fig. 5.39.3.1.4.1 and 2 display the stratified abundance indices of GSA 19 in 1994-2009. These size compositions are considered preliminary.

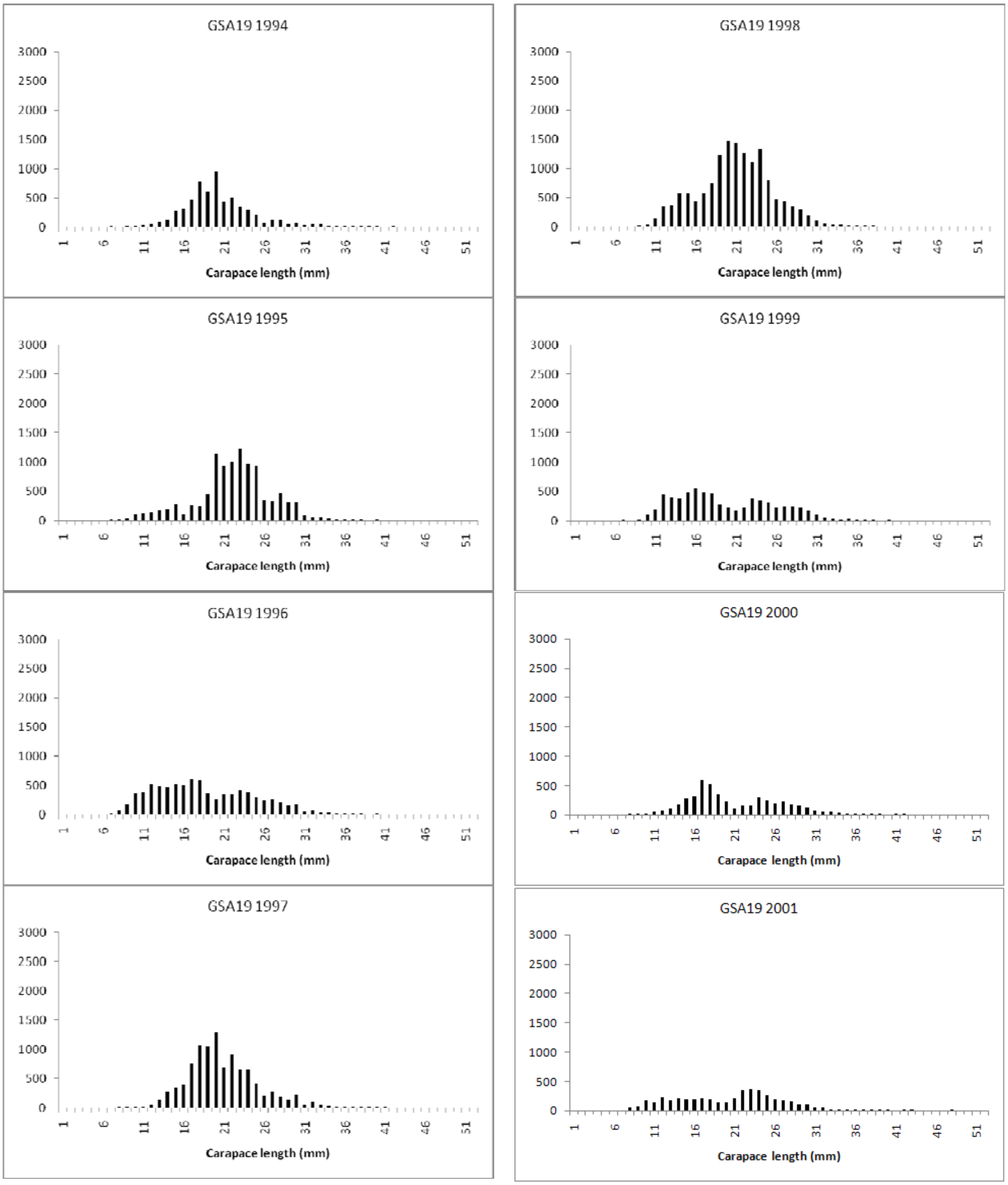


Fig. 5.39.3.1.4.1 Stratified abundance indices by size, 1994-2001.

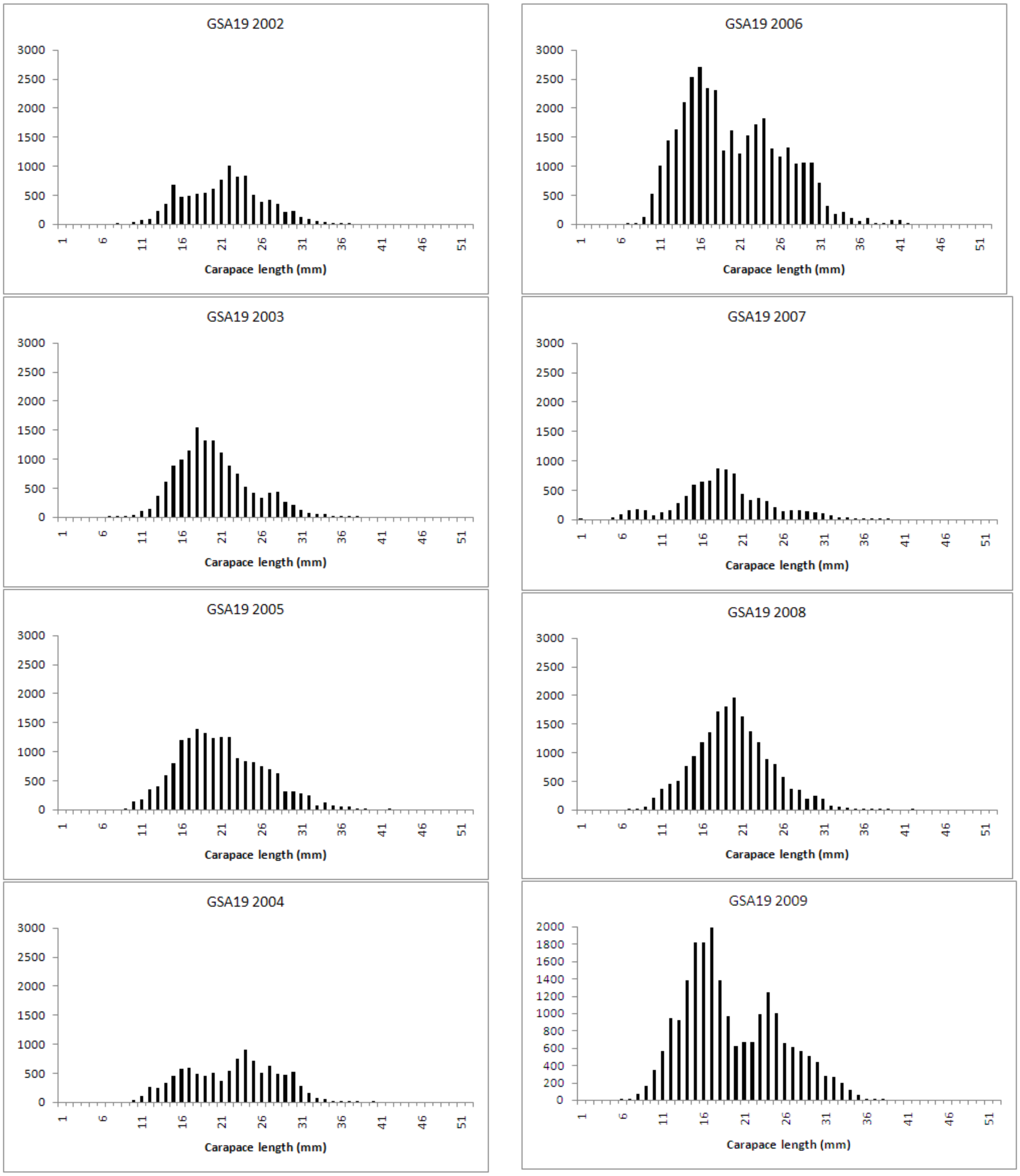


Fig. 5.39.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.39.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.39.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.39.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.39.5. Long term prediction

5.39.5.1. Justification

No forecast analyses were conducted.

5.39.5.2. Input parameters

No forecast analyses were conducted.

5.39.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for pink shrimp in GSA 19.

5.39.6. Scientific advice

5.39.6.1. Short term considerations

5.39.6.1.1. State of the spawning stock size

In the absence of proposed or agreed management reference points, SGMED-10-02 is unable to fully evaluate the state of the stock and to provide scientific advice. However, survey abundance and biomass indices appear increasing since 2002 with the maximum observed in 2009.

5.39.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.39.6.1.3. State of exploitation

In the absence of proposed or agreed management reference points SGMED-10-02 is unable to fully evaluate the exploitation state of the stock and to provide scientific advice.

5.40. Stock assessment of pink shrimp in GSAs 22 and 23 combined

5.40.1. Stock identification and biological features

5.40.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.40.1.2. Growth

No information was documented during SGMED-10-02.

5.40.1.3. Maturity

No information was documented during SGMED-10-02.

5.40.2. Fisheries

5.40.2.1. General description of fisheries

The pink shrimp stock is exploited by the Greek and Turkish fishing fleets. The bottom trawl fishery in Greece is a mixed fishery, operating from the beginning of October until the end of May, as a 4-month fishery closure (June-September) for bottom-trawlers is enforced by national legislation. The minimum mesh size of the cod end of bottom trawls is 40 mm.

5.40.2.2. Management regulations applicable in 2009 and 2010

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone 1.5 mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1^{st} of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2010, the net should have been replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship-owner, by a diamond meshed net of 50 mm. So far, only a few boats have actually replaced their nets.

Several additional restrictions exist for bottom trawling in specific areas. For example in Amvrakikos Gulf, Pagassitikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1^{st} of March till the end of November.

5.40.2.3. Catches

5.40.2.3.1. Landings

Estimation of landings was based on random sampling in 127 sampling stations (ports) in GSA 22-23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and landings by species recorded. Based on these data, average landings per fishing day, by species and for each fishing gear were estimated. Based on total effort estimations, sampled data were raised to the whole fleet to estimate total landings by species, fleet segment, fishing gear and GSA.

Tab. 5.40.2.3.1.1 shows the trend in reported landings taken by major gear types. The data were reported through the Data Collection Regulation.

Tab. 5.40.2.3.1.1 Greek landings (t) by year and major gear types, 2003-2008 as reported through DCF.

SPECIES	AREA	COUNTRY	FT_LVL4	<>	2002	2003	2004	2005	2006	2007	2008
DPS	20	GRC	GTR			4	3	8	15		2
DPS	20	GRC	OTB			273	419	94	307		105
DPS	20	GRC	SB			5					
DPS	22	GRC	GTR			207	98	72	124		97
DPS	22	GRC	OTB			867	3258	3926	4053		3745
DPS	22	GRC	SB								57

5.40.2.3.2. Discards

No discards data were reported to SGMED-10-02 through the DCF data call for Greece.

5.40.2.3.3. Fishing effort

Estimation of effort was based on interviews conducted with random sampling in 127 sampling stations (ports) in GSA 22-23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive, and the proportion of the year they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, fishing gear, and GSA. It should be noted that the estimated effort refers to the entire effort of each fleet segment.

Tab. 5.40.2.3.3.1 lists the fishing effort reported to SGMED-10-02 through the DCR data call.

Tab. 5.40.2.3.3.1 Fishing effort in different units by fishing technique deployed in GSA 22 and 23, 2003-2008.

TYPE	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DAYS	22	GRC	GTR		2078058	1908626	1993815	1914951		1374948
DAYS	22	GRC	LLS		20905	41155	41568	51501		302098
DAYS	22	GRC	OTB		52536	53381	56580	53367		51855
DAYS	22	GRC	PS		44481	43772	48211	42874		40029
DAYS	22	GRC	SB		36266	31987	33200	30098		25138
GT*DAYS	22	GRC	GTR		8567144	8034837	7939836	7571041		5309125
GT*DAYS	22	GRC	LLS		332005	577572	603419	780138		1244484
GT*DAYS	22	GRC	OTB		4927349	4972085	5553804	5556446		5355704
GT*DAYS	22	GRC	PS		1998124	1987556	2295466	2108039		1930332
GT*DAYS	22	GRC	SB		294896	269645	276265	257271		214985
KW*DAYS	22	GRC	GTR		68845607	70633794	70746878	66780942		50244080
KW*DAYS	22	GRC	LLS		1888201	4977272	2715667	3848302		7914684
KW*DAYS	22	GRC	OTB		15792715	15874762	17730748	16424382		16013057
KW*DAYS	22	GRC	PS		9389351	9140980	9656463	8992650		8233643
KW*DAYS	22	GRC	SB		2775797	2206815	2193550	2022231		1774864

5.40.3. Scientific surveys

5.40.3.1. Medits

5.40.3.1.1. Methods

The MEDITS survey was carried out in GSAs 22-23 every summer from 1994 to 2008, except in 2002, 2007 and 2009 because of administrative problems. In GSA 22 and 23, the number of stations was 98 in 1994 and gradually increased to 146 in 1996 and onwards. Due to this change in the survey design, caution is needed when investigating the trends of relevant indicators in the MEDITS time series unless the data are properly standardised. More details on methodology and trends on selected indicators may be found in MEDITS (2007).

Based on the DCR data call, abundance and biomass indices were calculated. In GSAs 22 and 23 the following number of hauls was reported per depth stratum (Tab. 5.40.3.1.1.1).

Tab. 5.40.3.1.1.1. Number of hauls per year and depth stratum in GSAs 22 and 23, 1994-2008.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GSA22+23_010-050	10	10	11	10	13	12	13	13		13	13	14	14		13
GSA22+23_050-100	19	21	22	28	24	26	21	25		25	23	24	24		27
GSA22+23_100-200	19	26	38	36	36	33	38	35		36	43	41	41		40
GSA22+23_200-500	32	35	45	50	51	54	50	48		51	53	52	52		52
GSA22+23_500-800	18	13	19	22	22	21	20	17		17	17	17	17		17

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration.

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution or a quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (sub-samples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.40.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.40.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of pink shrimp in GSAs 22 and 23 was derived from the international survey MEDITS. Fig. 5.40.3.1.3.1 displays the estimated trend in pink shrimp abundance and biomass in GSAs 22 and 23.

The estimated abundance and biomass indices reveal a general increasing trends since 1994. However, the abundance and biomass indices are subject to high uncertainty.

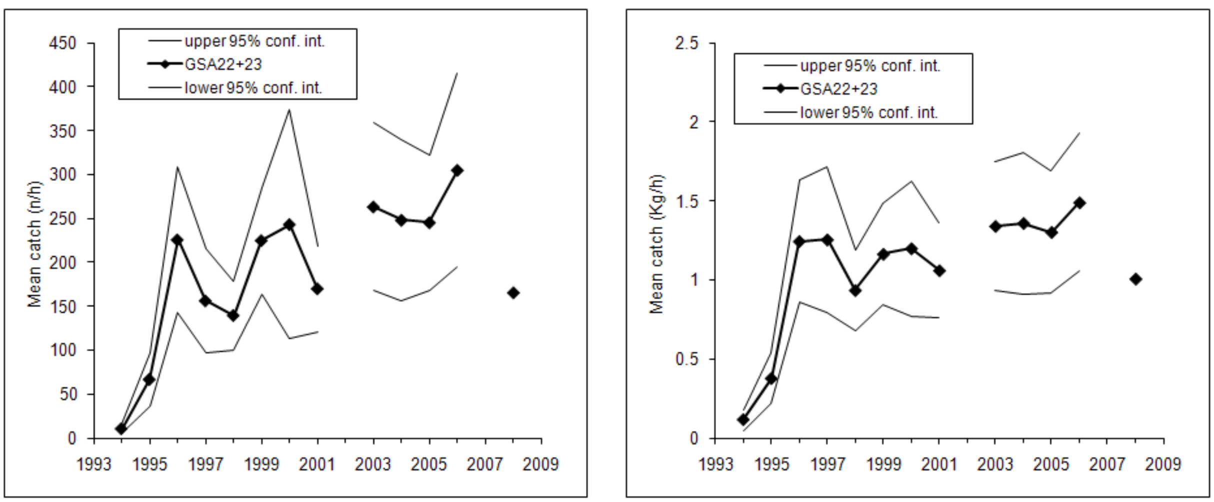


Fig. 5.40.3.1.3.1 Abundance and biomass indices of pink shrimp in GSAs 22 and 23.

5.40.3.1.4. Trends in abundance by length or age

The following Fig. 5.40.3.1.4.1 and 2 display the stratified abundance indices of GSAs 22 and 23 combined in 1994-2001 and 2003-2008. These size compositions are considered preliminary.

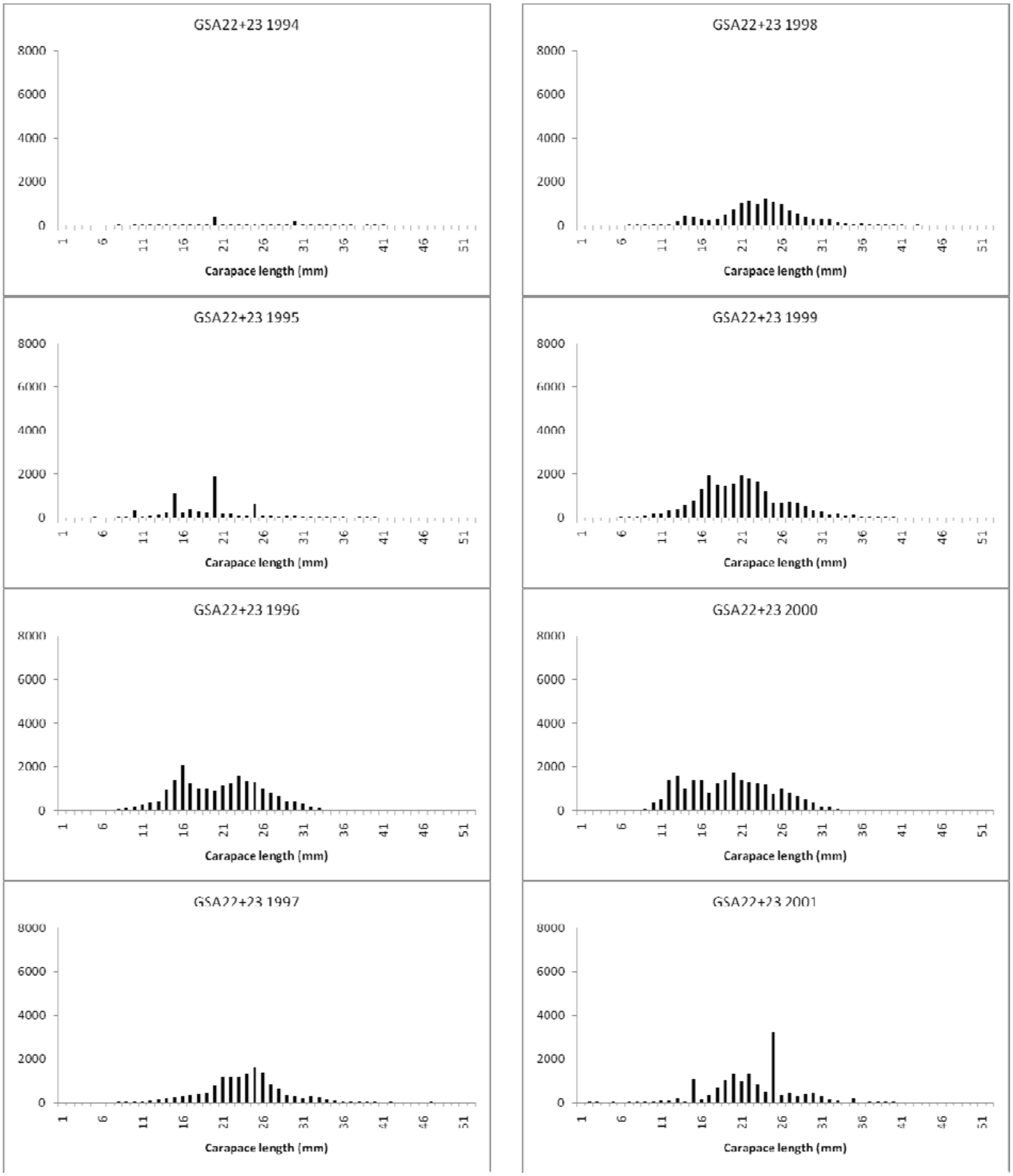


Fig. 5.40.3.1.4.1 Stratified abundance indices by size, 1994-2001.

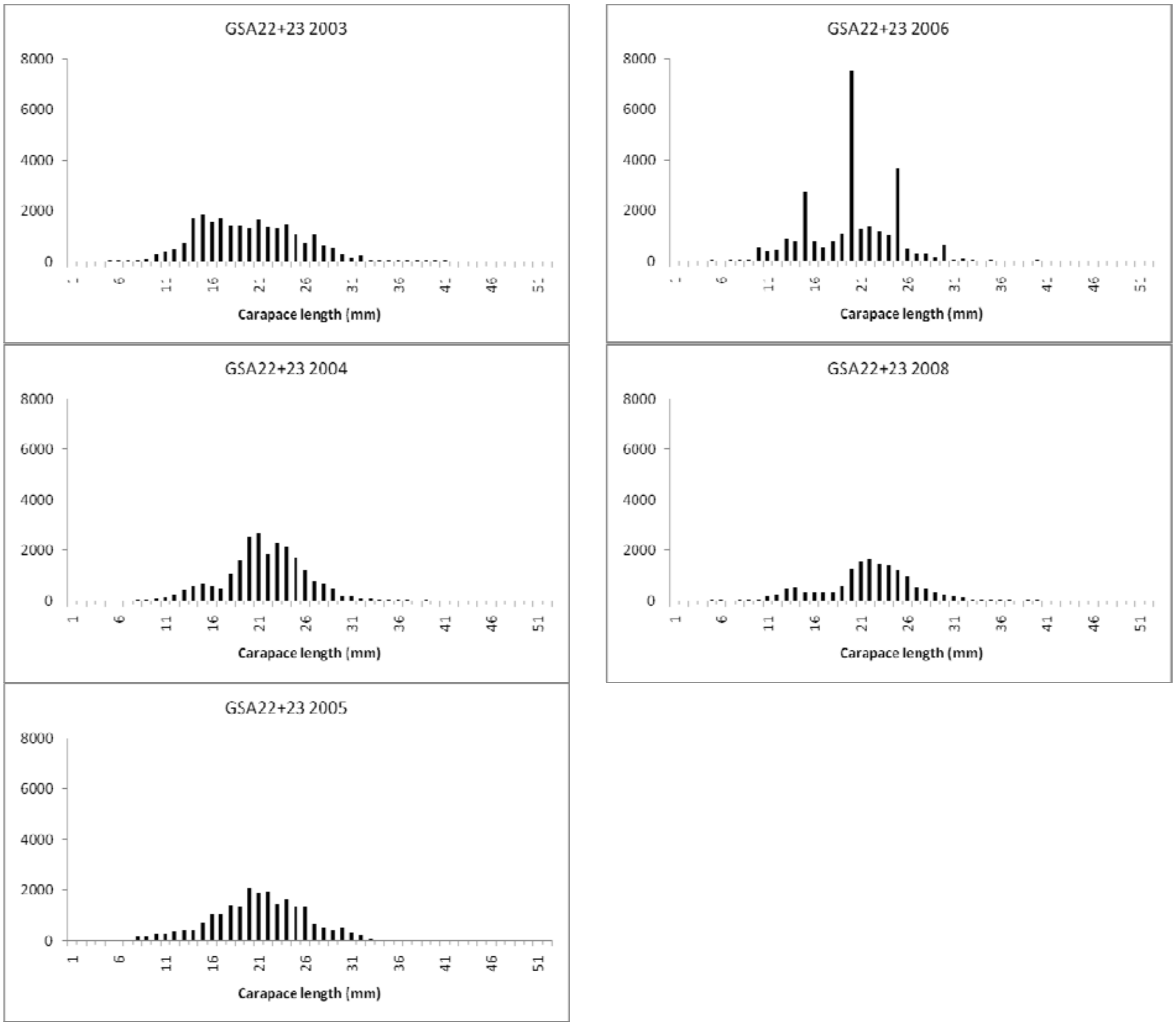


Fig. 5.40.3.1.4.2 Stratified abundance indices by size, 2003-2008.

5.40.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.40.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.40.4. Assessment of historic stock parameters

A new assessment is presented based on surplus production. Age-based assessments could not be carried out due to lack of sufficient catch-at-age information. Attempts to analyse MEDITS survey data through the SURBA software failed as not proper model fitting was achieved.

5.40.4.1. Method 1: Surplus production model

5.40.4.1.1. Justification

The assessment estimates for the pink shrimp (*Parapenaeus longirostris*) stock were based on the logistic surplus production model (Schaefer, 1954) using a non-equilibrium approach which utilizes a time series of CPUE and landings data (Tserpes, 2008).

The model is described below:

For a given *r* value the following approach has been followed:

1. Estimation of harvest rate for the beginning of the period

$$hr = \frac{F}{Z} \times (1 - e^{-Z})$$

2. Estimation of initial biomass fraction (i.e. B/k)

$$B_{fr} = 1 - \frac{hr}{r}$$

3. Estimation of a starting *k* value

$$k_{in} = \frac{C_{av} \times 4}{r}$$

(assumes that average catch is around to MSY).

4. Estimation of initial biomass

$$B_0 = B_{fr} \times k_{in}$$

5. Estimation of a starting *q* value

$$q_{in} = \frac{U_{av}}{B_0}$$

(U_{av}=mean abundance index)

6. Final estimates of model parameters *(k, q)* were obtained using a least squares criterion of fit assuming log-normally distributed residual errors between observed and expected abundance indices.

The equations used were:

$$B_t = B_{t+1} + rB_{t-1}(1 - \frac{B_{t-1}}{k}) - C_{t-1}$$

$$U_t = q \times B_t$$

$$\varepsilon_t = (\log U_t - \log \hat{U}_t)^2$$

$$U_t = (B_{t-1} + rB_{t-1}(1 - \frac{B_{t-1}}{k}) - C_{t-1}) \times q$$

The above steps have been repeated for a series of consecutive r values (range 0.30-0.99, interval 0.01). As the best model, was considered that providing the lowest error and its parameters were used to calculate population biomass time series as well as equilibrium MSY, B_{msy} and F_{msy} rates. Confidence intervals were estimated through bootstrapping. Model estimates were made by means of computer code developed in R-language.

5.40.4.1.2. Input parameters

Total Greek Aegean landings of pink shrimp by year for the period 1990-2006 were extracted from the National Statistical Service of Greece (NSSG) database and reconstructed to include small scale coastal fisheries catches based on the approach by Tsikliras et al. (2007) (Table 5.40.4.1.2.1). Landings of the eastern Aegean (Turkey) were extracted from the GFCM database.

Table 5.40.4.1.2.1 Pink shrimp Aegean landings (in kg) for the period 1990-2006.

Year	**Landings (kg)**
1990	1888513
1991	1824329
1992	2163206
1993	1694702
1994	1496383
1995	1343222
1996	1578755
1997	2030731
1998	1788189
1999	1671383
2000	1454717
2001	1393277
2002	1839917
2003	2165687
2004	2246627
2005	3393460
2006	2363180

A yearly index of MEDITS CPUE series for the period 1996-2006 (excluding 2002 for which no data were available) based on data from the MEDITS project for GSA 22 and 23 (www.ifremer.fr/Medits_indices) (Table 5.40.4.1.2.2).

Table 5.40.4.1.2.2 Pink shrimp in GSA 22-23. MEDITS CPUE index for 1996-2006.

Area	Year	CPUE index
22	1996	18.278
22	1997	19.043
22	1998	12.670
22	1999	16.179
22	2000	16.751
22	2001	14.522
22	2002	-
22	2003	19.334
22	2004	18.320
22	2005	16.284
22	2006	16.755

Exploitation rate at the beginning of the studied period are based on the mortality estimates of the latest VPA assessment. Values of F and M for the beginning of the period were fixed to 1.00 and 0.6 respectively.

5.40.4.1.3. Results

The best fit was provided for r=0.72 (0.60-0.85) and k=12668 t (10690-14645). Based on the above estimates, equilibrium MSY was 2299 t (Figure 5.40.4.1.3.1). The corresponding rates for fishing mortality and biomass were: F_{MSY} =r/2=0.36 and B_{MSY} =k/2=6334 t. Annual catches in the last two years are slightly exceeding MSY, while stock biomass levels are constantly lower than B_{MSY} without any trend (Figure 5.40.4.1.3.2). CPUE fluctuates with no trend (Figure 5.40.4.1.3.3).

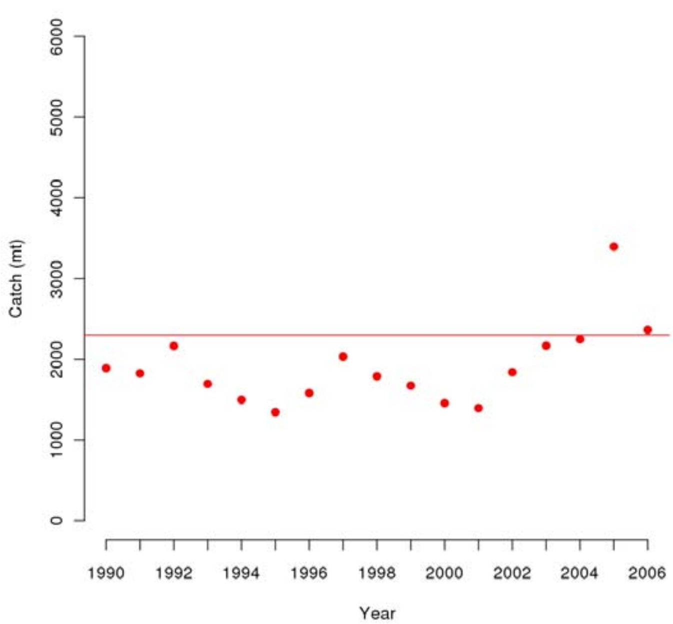


Figure 5.40.4.1.3.1. Pink shrimp catch by year (red points) and MSY levels (red horizontal line).

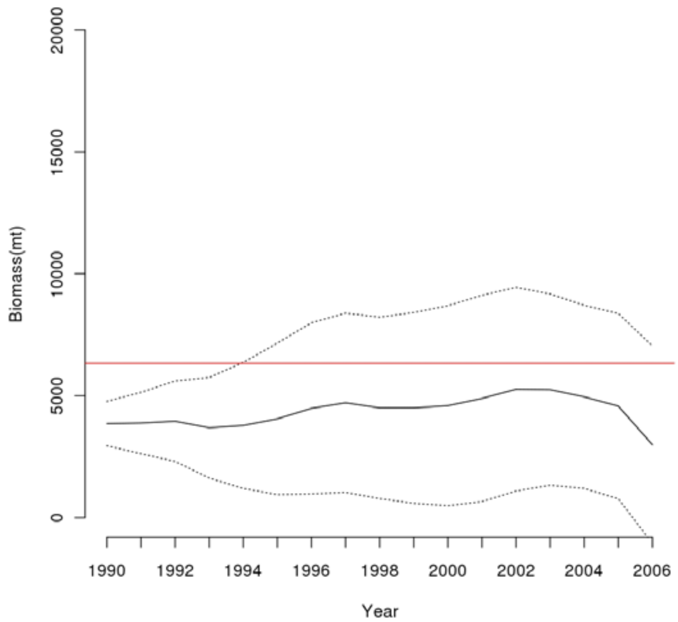


Figure 5.40.4.1.3.2. Pink shrimp biomass (black solid line) by year and BMSY levels (red horizontal line).

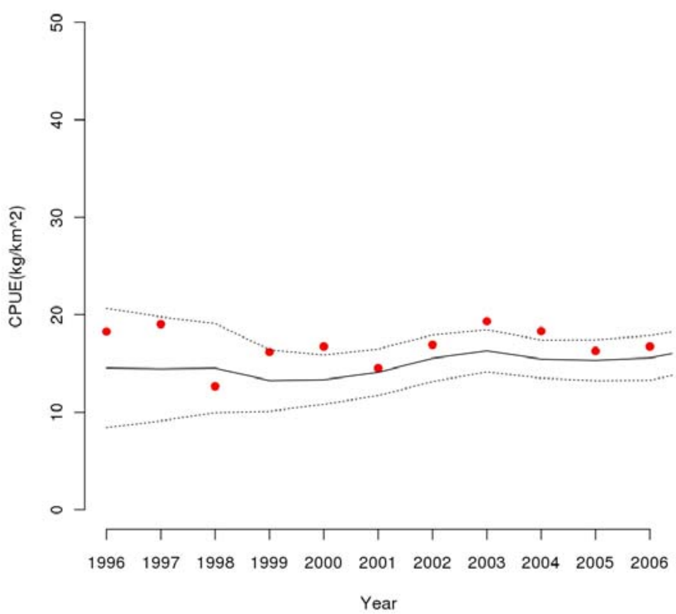


Figure 5.40.4.1.3.3. Pink shrimp CPUE by year (red points) and model fitted line.

5.40.5. Long term prediction

5.40.5.1. Justification

A Y/R analysis was conducted using the Yield software.

5.40.5.2. Input parameters

Growth parameters

L_{inf}	4
k	0.55
to	-0.20

Weight-length relationship

a (W-L)	0.4
b (W-L)	3

Natural mortality 0.45
Age at maturity 1.5
Age at first capture 0.7

5.40.5.3. Results

Table 5.40.5.3.1 lists the reference points estimated from the yield per recruit analysis.

Table 5.40.5.3.1. Fisheries management reference values derived from yield per recruit analysis.

	Y/R
F_{MSY}	0.60
$F_{0.1}$	0.34

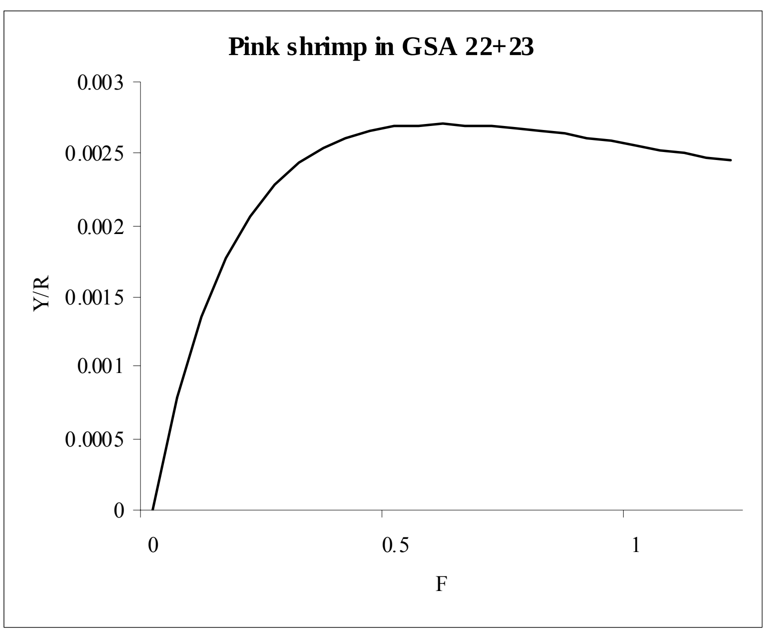


Figure 5.40.5.3.1. Yield (kg) per recruit for pink shrimp in GSA 22+23.

5.40.6. Data quality

The lack of catch-at-age data did not allow the use of an age-based assessment that would provide a more detailed and robust information about the stock status. The quality of existing data did not seem to have any negative effect on the applied models. However, SGMED notes that due to lack of recent data, the assessment relies on data up to 2006 only and a more recent assessment of stock is lacking. Also, SGMED considers that the interruption of the survey time series and the lack of catch and weight at age data from the landings will preclude the assessment and management of pink shrimp in GSA 22-23 in the next years.

5.40.7. Scientific advice

5.40.7.1. Short term considerations

5.40.7.1.1. State of the spawning stock size

In the absence of proposed and agreed precautionary reference points SGMED-10-02 is unable to fully evaluate the status of the SSB. SGMED-10-02 considers all analyses presented to assess the status of pink shrimp in GSAs 22 and 23 as preliminary and not suitable to provide sound scientific advice. Moreover, the lack of data from 2007 and onwards preclude a more recent assessment of the status of the stock.

5.40.7.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.40.7.1.3. State of exploitation

In the absence of proposed or agreed management reference points of exploitation consistent with high long term yields, SGMED-10-02 is unable to fully evaluate the state of the stock and provide scientific advice.

5.41. Stock assessment of anchovy in GSA 01

5.41.1. Stock identification and biological features

5.41.1.1. Stock Identification

Little or no specific work has been conducted on the stock identification of anchovy in the Western Mediterranean, but exchanges between the Northern Alboran Sea (GSA 01), the Northern Spain (GSA 06) and South Alboran Sea (GSA 03) are believed to be negligible. Based on the above considerations, STECF-SGMED-08-02 recommends continuing the assessments on GFCM-GSA basis. Figure 5.41.1.1.1 shows the GFCM Geographical Sub-Area GSA 01 (Northern Alboran Sea).

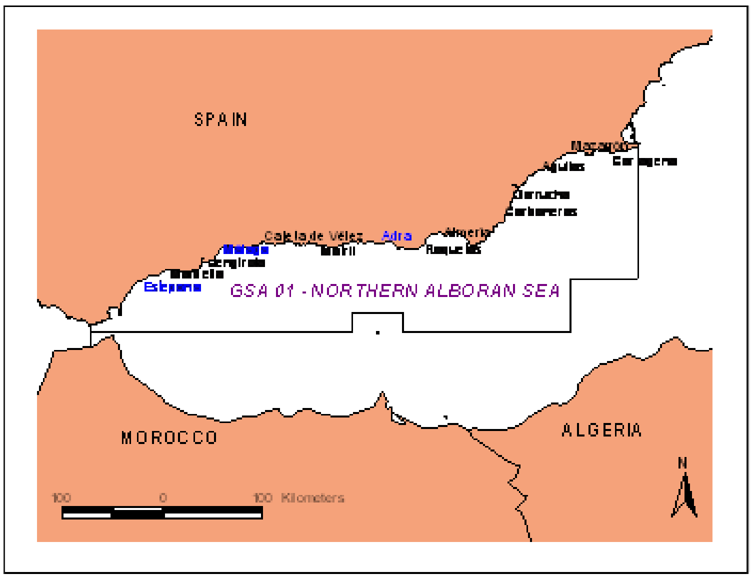


Fig. 5.41.1.1.1 Stock distribution area.

5.41.1.2. Growth

Growth parameters were estimated throughout the DCR biological sampling on a triennial basis (Table 1). The method used was the Von Bertalanffy growth equation fit to age (obtained through otoliths reading) and length data using non-linear estimation with minimum least squares (Gauss-Newton algorithm) and bootstrapped precision estimates.

Tab. 5.41.1.2.1 Growth parameters and Length-Weight relationship.

PERIOD	L8	k	t0	a	b
2002-2004	19.0	0.3395	-1.8815	0.0029	3.3171
2005-2007	19.0	0.3419	-2.3210	0.0040	3.1945
2008-2009	19.0	0.4237	-1.8801	0.0033	3.2761

5.41.1.3. Maturity

Maturity at age was estimated throughout the DCR biological sampling from years 2003-2007. These values were considered constant through the years of the assessed time series (2002-2007).

Tab. 5.41.1.3.1 Maturity ogive.

Age	0	1	2	3
Prop Matures	0.50	0.89	1.0	1.0

5.41.2. Fisheries

5.41.2.1. General description of fisheries

The current fleet in GSA 01 the Northern Alborán Sea is composed by 131 units, characterised by small vessels. Around 21% of them are smaller than 12 m and 79% are between 12 and 24 m. The purse seine fleet has been continuously decreasing in the last two decades, from more than 230 vessels in 1980 to 131 in 2009 (Fig. 5.41.2.1.1). Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the main target species of the purse seine fleet in Northern Alboran GSA 01, but other species with lower commercial value as horse mackerel (*Trachurus spp.*), mackerel (*Scomber spp.*) and gilt sardine (*Sardinella aurita*) are also caught.

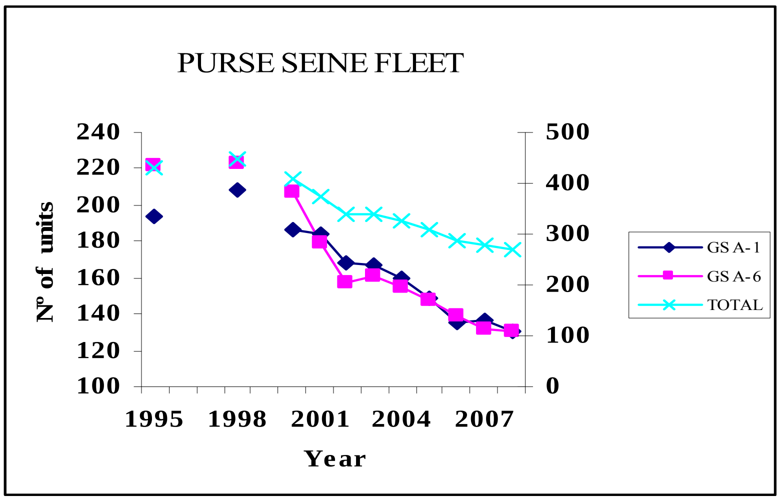


Fig. 5.41.2.1.1 The current fleet in GSA 01 the Northern Alborán Sea.

5.41.2.2. Management regulations applicable in 2009 and 2010

- Fishing license.
- Minimum landing size 11cm.
- Time at sea 12 hours per day and 5 days a week (no fishing allowed on weekend).
- Several technical measures regulations (gear and mesh size, engine, GRT, etc.).
- Temporary fishing closures (March and April).

5.41.2.3. Catches

5.41.2.3.1. Landings

The annual landings of anchovy in the Northern Alborán Sea show annual fluctuations ranged between 3268 and 178 tons. Landings increase in 2009, reaching up 292 t. The data were reported to SGMED-10-02 through the Data Collection Regulation and are listed in Table 5.41.2.3.1.1.

Tab. 5.41.2.3.1.1 Annual landings (t) by fishing technique (Spanish purse seiners) in GSA 01.

SPECIES	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008	2009
ANE	1	ESP	PS	3268	245	746	518	637	245	178	292

5.41.2.3.2. Discards

Anchovy discards in GSA 01 are considered negligible.

5.41.2.3.3. Fishing effort

No effort data were reported by Spain to SGMED-10-02 through the DCF data call. Thus, SGMED were unable to conduct an analysis of the effort trend for the major fleets fishing anchovy in GSA 01.

5.41.3. Scientific surveys

5.41.3.1. ECOMED Acoustic Survey

5.41.3.1.1. Methods

ECOMED and MEDIAS Acoustic Surveys allows for the estimation of abundance index of anchovy in GSA 01 (Biomass in metric tons and abundance in number of individuals by species and area).

The ECOMED survey provided data from 1990 to 2008, although the abundance time series used for XSA tuning range from 2003 to 2008 as 1990-2002 acoustic data are currently being re-evaluated. As a result of a gradual increase in the abundance of other species, it has been necessary to revaluate the 1990-2002 acoustic data from ECOMED surveys using different values of the target strength (TS) parameter.

The ECOMED survey covered the entire GSA 01 only in 2004 and 2005, while the survey did cover only the two most important bays in 2003 and 2006. No data for 2007 was available due to bad weather conditions and lack of time.

The ECOMED surveys were carried out on board the R/V Cornide de Saavedra during late autumn (November-December). A multifrequency echosounder is utilised (SIMRAD-ER60) sampling at frequencies of 38 kHz, 70 kHz, 120 kHz and 200 kHz. The ESDU is 1 nm. The pulse duration is 1 msg. The software used for echogram identification was *SonarData Ecoview*.

During ECOMED, the sampling grid is constituted by parallel tracks, perpendicular to the coast. Acoustic sampling is performed during daytime. Experimental fishing with pelagic trawl for schools identification was done at night in the previously tracked positions.

The new MEDIAS acoustic survey was carried out during the summer (June-July) for the first time in 2009. MEDIAS used the same vessel, the same echosounder and the same sampling grid withECOMED but experimental fishing with pelagic trawl for schools identification was done during the day.

However, MEDIAS sampling coverage was incomplete in 2009 due to logistic problems and no data for GSA 01 was available.

5.41.3.1.2. Geographical distribution patterns

Anchovy in North Alborán Sea (GSA 01) is concentrated in Málaga Bay. This Bay is the most important recruitment and fishery area and this represent 85% of the total landings.

5.41.3.1.3. Trends in abundance and biomass

Both XSA and acoustics methods had the same perception of the state of the stock. During the period from 1996-2009, the catches of anchovy stock in the Alborán Sea showed marked fluctuations. A successful recruitment, estimated by echo-acoustic tracking, was observed during 2001 producing a strong increase of landings in 2002. The catch dropped in 2003 and continued at low level to 2009 (292 tons). This decline is consistently estimated with both XSA and acoustics survey methods (Figure 5.41.3.1.3.1 and 5.41.3.1.4.1).

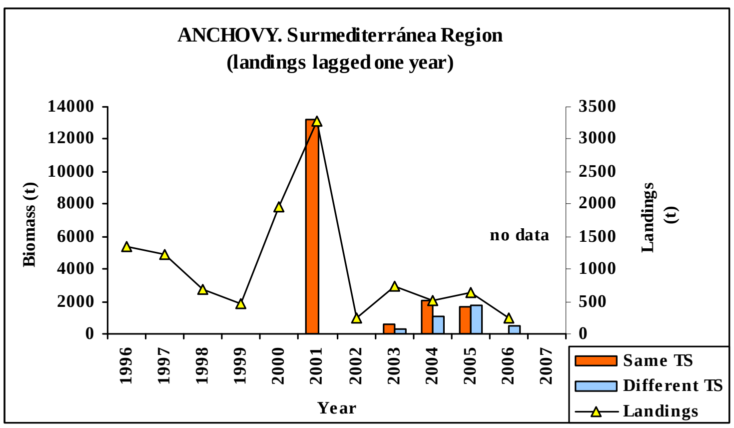


Fig. 5.41.3.1.3.1 Trends in biomass estimates and landings.

5.41.3.1.4. Trends in abundance by length or age

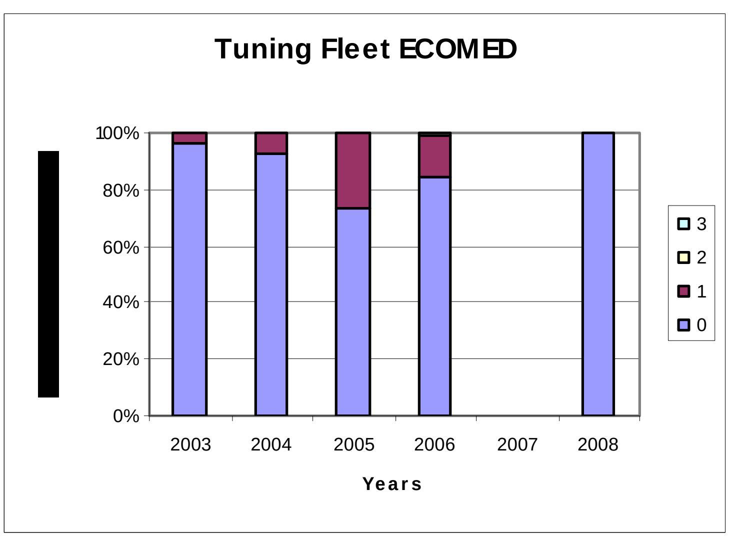


Fig. 5.41.3.1.4.1 Age compositon of the stock.

5.41.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.41.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.41.4. Assessment of historic stock parameters

5.41.4.1. Method 1: VPA-XSA

The assessment of this stock was carried out by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999) using catch data collected by the Spanish National Data Collection. The XSA tuning was performed using abundance index series derived from echo-surveys carried out in the GSA 01.

This is the third assessment of *Engraulis encrasicolus* from GSA 01 using XSA. The 2008 assessment can be found in the report of SGMED-08-04 working group (Cardinale et al., 2008) and the 2009 assessment can be viewed at http://www.gfcm.org.

5.41.4.1.1. Justification

The length of the data series available (8 years, from 2002 to 2009) allowed the use of a VPA tuned with data from surveys (XSA). The software used was the Lowestoft suite (Darby and Flatman 1994) in 2008 and 2009, and FLR 2.2 packages in 2010.

5.41.4.1.2. Input parameters

- Landings time series 2002-2009 from all fishery ports in GSA 01.
- Combined ALK (2003-2009) for all the years (DCF official data).
- Length distributions 2003-2009 (DCF official data). For 2003, length distributions estimated in 2002 were applied.
- Biological sampling 2003-2009 for Maturity at Age and Weight-Length relationships (DCF official data).
- Tuning data from acoustic surveys ECOMED 2003-2008 (DCF official data).

Table 5.41.4.1.2.1 Landings (t) 2002-2009.

2002	2003	2004	2005	2006	2007	2008	2009
3268	245	746	518	637	245	178	292

Table 5.41.4.1.2.2 Catch numbers at age 2003-2009 (thousands).

	2002	2003	2004	2005	2006	2007	2008	2009
Age 0	393872	29528	40762	18580	12997	16342	4537	43706
Age 1	46740	3504	18525	13377	16136	5120	3881	3381
Age 2	6272	470	4128	3997	7340	1241	2093	256
Age 3	209	16	132	186	450	107	177	10

Table 5.41.4.1.2.3 Catch and stock weight at age (kg), 2003-2009.

	2002	2003	2004	2005	2006	2007	2008	2009
Age 0	0.007	0.007	0.010	0.012	0.014	0.009	0.012	0.006
Age 1	0.012	0.012	0.015	0.016	0.018	0.014	0.017	0.010
Age 2	0.020	0.020	0.020	0.021	0.022	0.023	0.022	0.020
Age 3	0.025	0.025	0.027	0.026	0.028	0.030	0.028	0.029

Table 5.41.4.1.2.4 Tuning data from ECOMED surveys 2003-2008.

	2002	2003	2004	2005	2006	2007	2008	2009
Age 0	-	45229	114290	86933	28429	-	575104	-
Age 1	-	1665	9029	31616	5117	-	1737	-
Age 2	-	0	0	0	191	-	0	-
Age 3	-	0	0	0	0	-	0	-

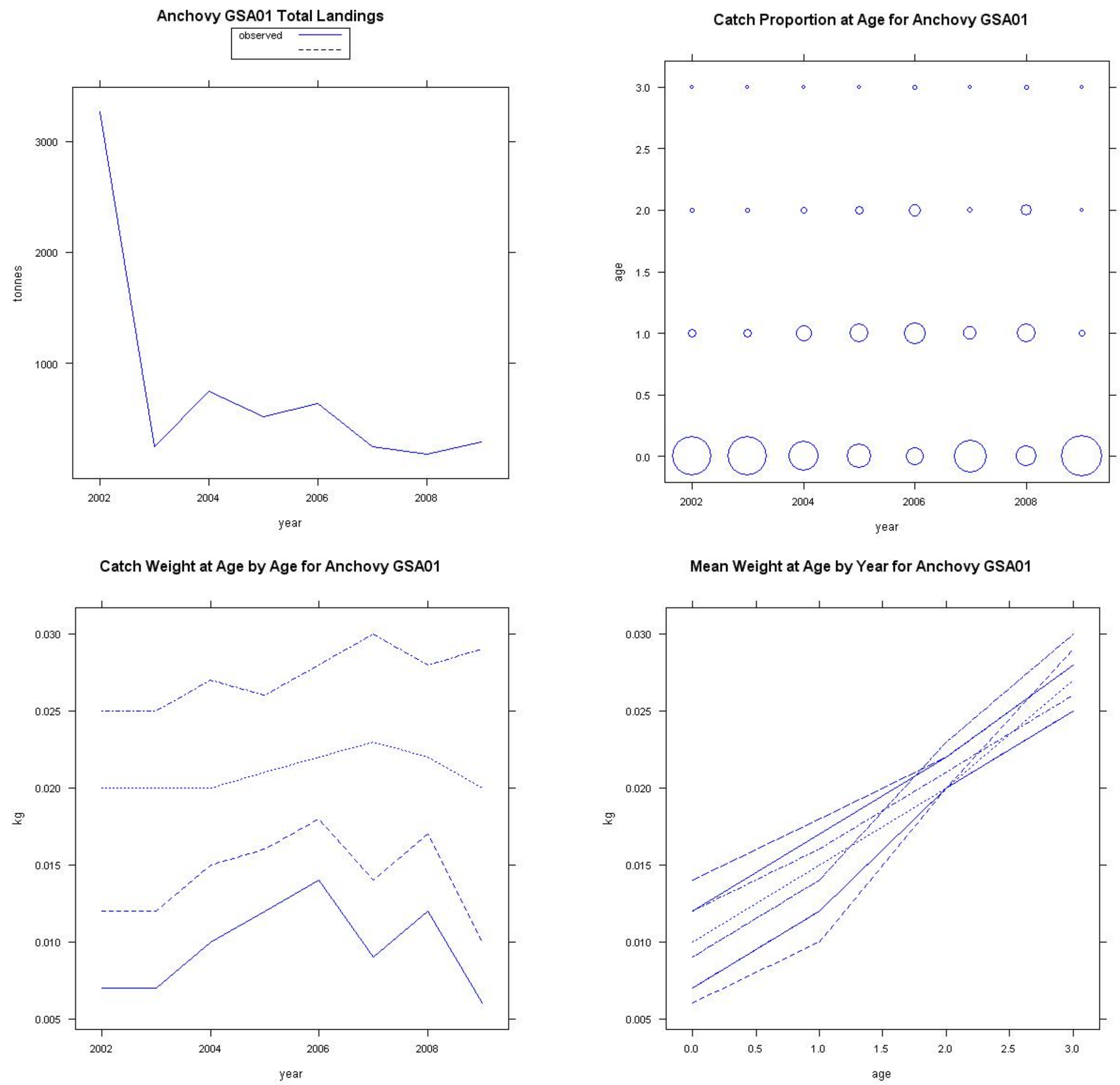


Fig. 5.41.4.1.2.1 Input data to the XSA.

Input parameters values are in accordance with STECF-SGMED recommendations.

Growth parameters (DCF official data)

PERIOD	L_INF	K	T0
2003-2004	19.0	0.3395	-1.8815
2005-2007	19.0	0.3419	-2.3210
2008-2009	19.0	0.4237	-1.8801

Length-weight relationships (DCF official data)

PERIOD	a	b
2003-2004	0.0029	3.3171
2005-2007	0.0040	3.1945
2008-2009	0.0033	3.2760

Maturity at Age (DCF official data)

Age	0	1	2	3
Prop Matures	0.50	0.89	1.0	1.0

A vector of natural mortality rate at age was estimated using PRODBIOM (Abella et al. 1997):

Age	0	1	2	3	Mean 0-3	Mean 0-2 (Ages Fbar)
M	1.17	0.43	0.32	0.27	0.55	0.64

5.41.4.1.3. Results

The main settings for the XSA are the following:

- Fbar 0-2.
- Age 1 for q stock-size independent.
- Age 2 for q independent of age.
- Fshrinkage = 0.500
- S.E. for fleet terminal estimates ≥ 0.300

XSA Diagnostics are shown in the next figures:

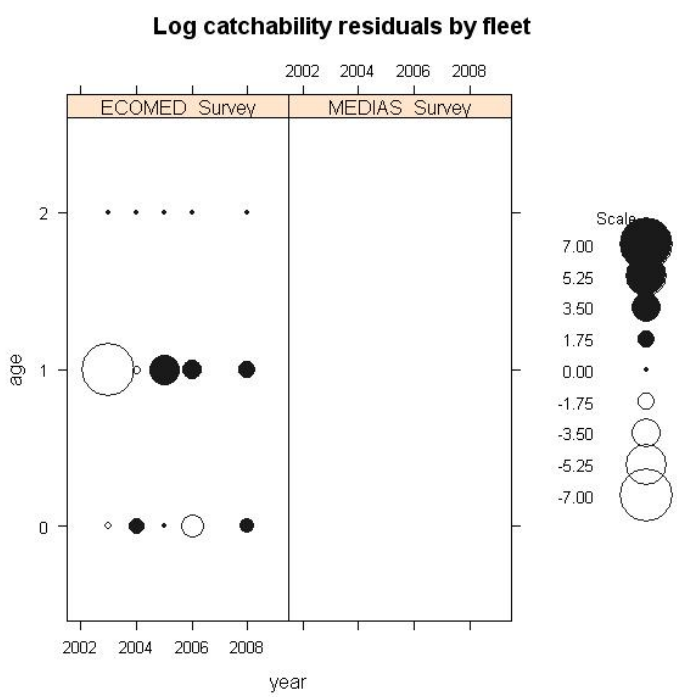


Fig. 5.41.4.1.3.1 Log catchability residuals by fleet.

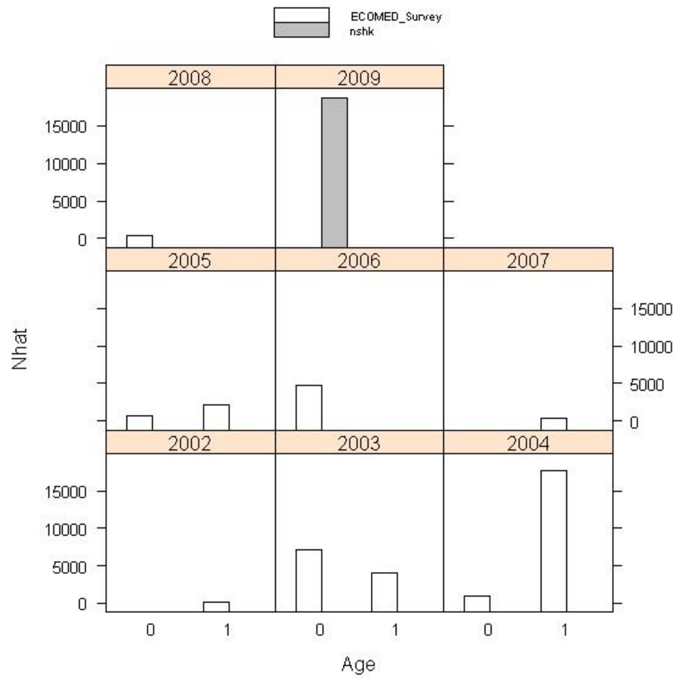


Fig. 5.41.4.1.3.2 Survivors by age.

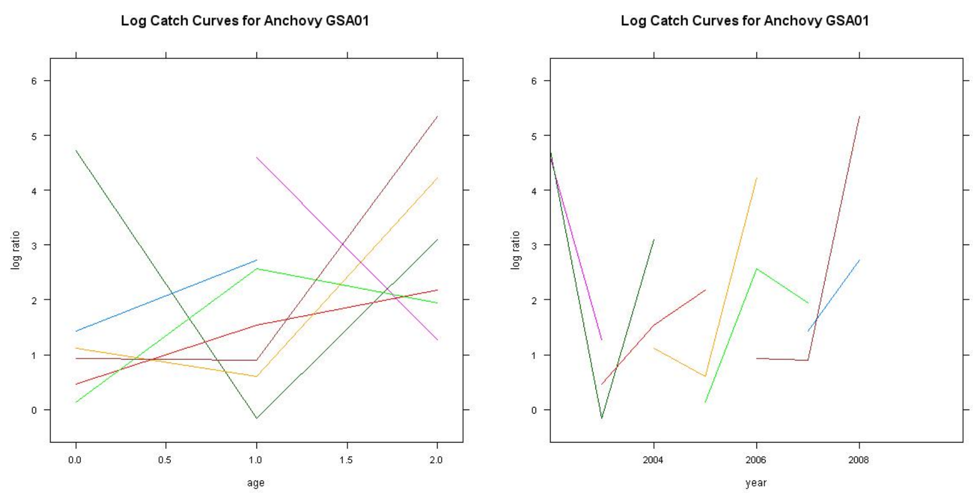


Fig. 5.41.4.1.3.3 Log Catch Curves by age and year.

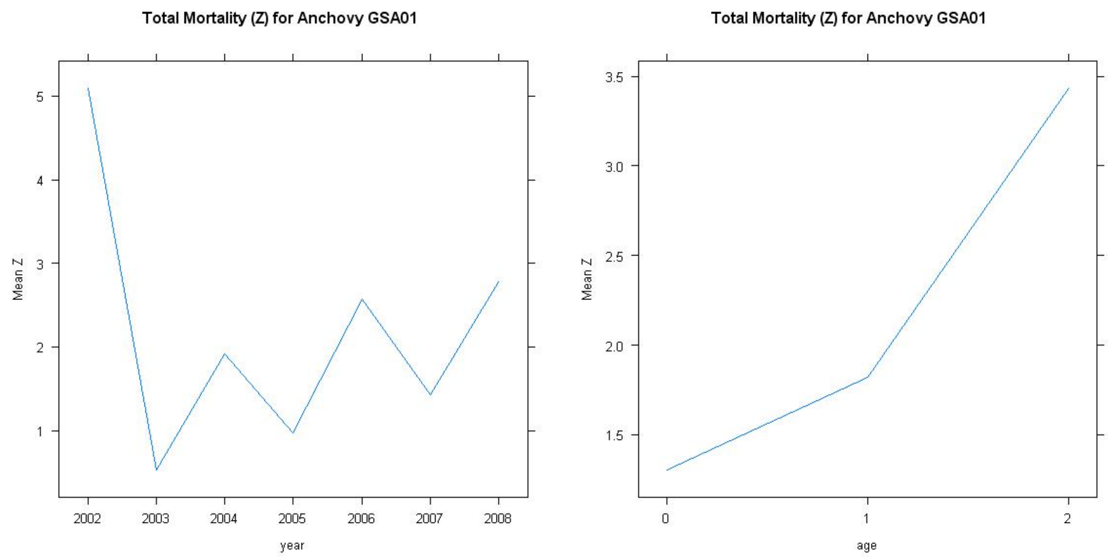


Fig. 5.41.4.1.3.4 Total Mortality (Z) by year and age.

The figures below present the main results from the XSA, the trends in biomass for mature and immature anchovies, and the stock-recruitment relationship.

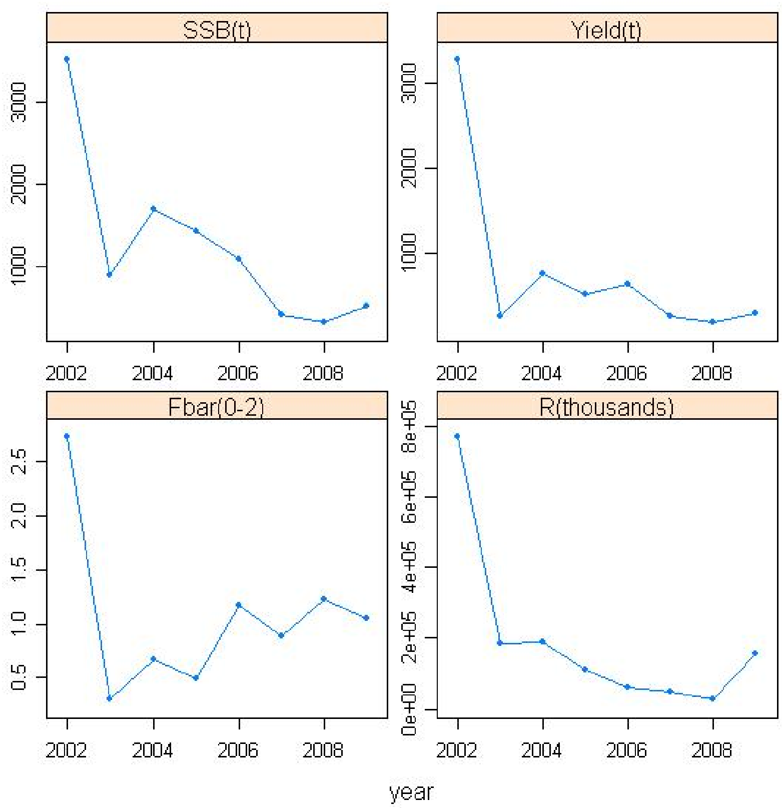


Fig. 5.41.4.1.3.5 Resulting stock parameters from the XSA.

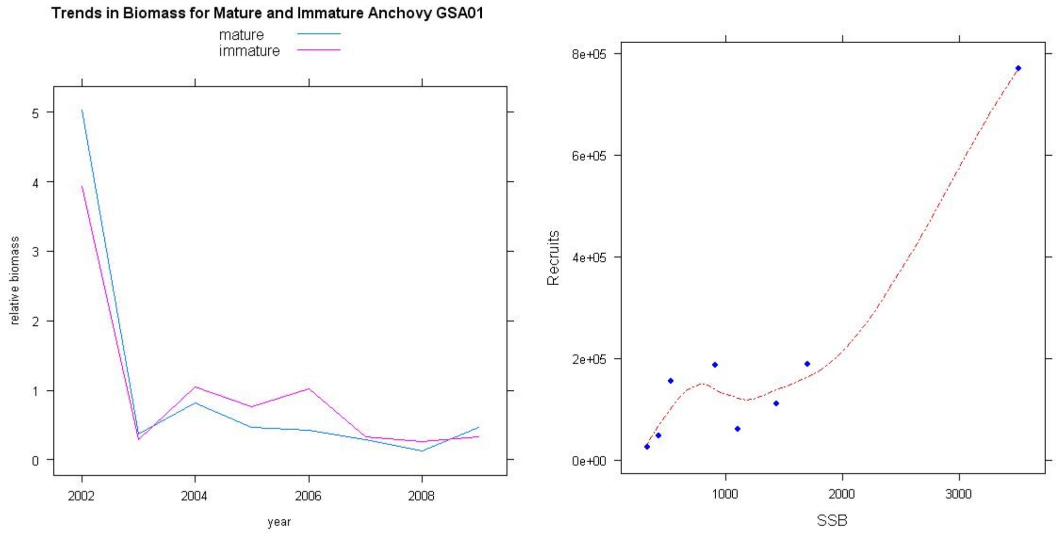


Fig. 5.41.4.1.3.6 Relative biomass estimates of mature and immature stock components and stock-recruitment relationship.

Tab. 5.41.4.1.3.1 Estimated fishing mortality at age, 2002-2009.

	2002	2003	2004	2005	2006	2007	2008	2009
0	2.5071	0.3351	0.4928	0.3612	0.4823	0.9746	0.3733	0.701
1	2.9208	0.2525	0.8115	0.6259	1.8376	0.784	2.0572	1.388
2	2.7774	0.2969	0.6779	0.4989	1.1857	0.8941	1.2307	1.064
3	2.7774	0.2969	0.6779	0.4989	1.1857	0.8941	1.2307	1.064

Tab. 5.41.4.1.3.2 Estimated stock numbers at age, 2002-2010.

	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	769730	186150	188040	110020	60968	47110	26143	155680	NA
1	61252	19470	41326	35653	23794	11682	5517	5586	23969
2	7848	2147	9840	11942	12403	2464	3470	459	907
3	244	354	1159	3627	5265	2752	732	736	115

Tab. 5.41.4.1.3.3 Stock summary table from the XSA without SOP correction. SSB (t); R (thousands).

	2002	2003	2004	2005	2006	2007	2008	2009
SSB	3511	904	1697	1433	1101	420	325	526
Fbar (1-3)	2.7351	0.2948	0.6607	0.4953	1.1685	0.8842	1.2204	1.0510
Recruitment	769730	186154	188040	110016	60968	47110	26143	155679

Retrospective analysis was applied in the XSA model for anchovy in GSA 01 with six year backward analysis. Results are presented in the next figure showing an underestimation of fishing mortality and no particular retrospective bias in recruitment and spawning biomass in recent years. However, fishing mortality appears to be underestimated in the last most recent years.

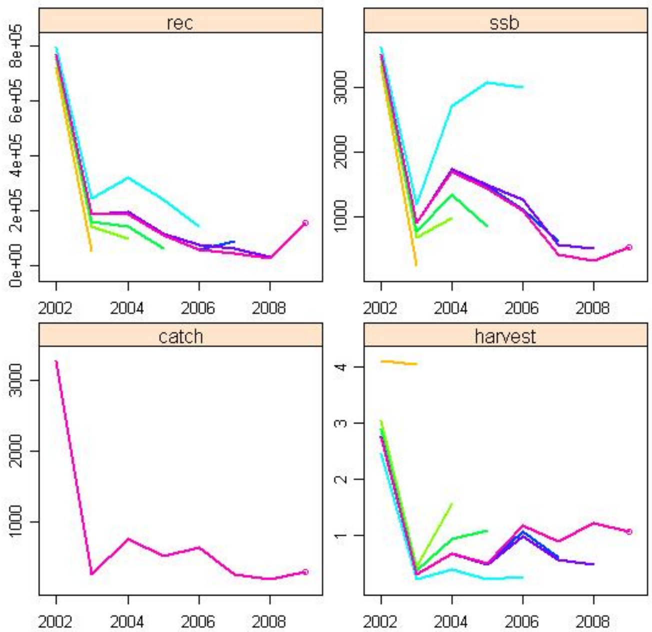


Fig. 5.41.4.1.3.7 Retrospective patterns of the stock assessments with identical parameter settings.

The annual exploitation rate E = F/(F+M) or F/Z was calculated and plotted over the years. The constant M value (0.64) was estimated as the mean of the 0-2 ages of the M vector. The values obtained were compared with the threshold F/Z = 0.4 adopted as biological reference point for small pelagics (Patterson, 1992) by SGMED.

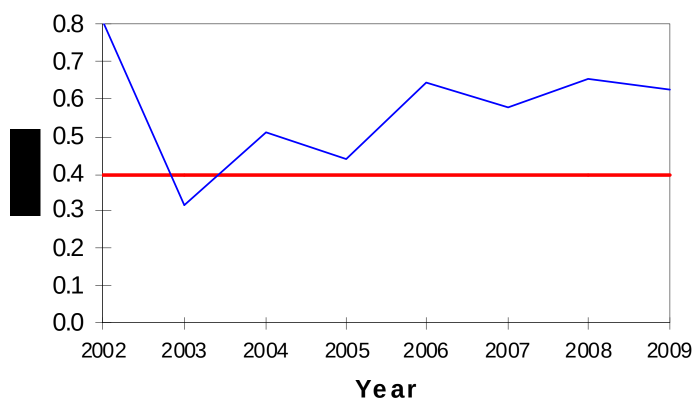


Fig. 5.41.4.1.3.8 The values of E=F/Z plotted over years and compared to the reference level of E=0.4.

Since 2002 fishing mortality (F_{0-2}) has varied between 2.7 and 0.5. The maximum was observed in 2002, then falling down to the minimum in 2003. Since then, F shows an increasing trend (F_{09}=1.05). The trend of the recruitments followed a decreasing trend from 2002 to 2008 showing a slight recovery in 2009 (156 millions). SGMED highlighted that the fishery is highly dependent of the recruitment strength. Spawning Stock Biomass in 2009 (526 t) shows a slight increase but remains at low levels after the decreasing trend observed since 2004.

5.41.5. Long term prediction

5.41.5.1. Justification

Yield per recruit analysis was conducted in the SGMED-10-02 assuming equilibrium conditions.

5.41.5.2. Input parameters

Yield per recruit analyses was conducted based on the exploitation pattern resulting from the XSA model and population parameters. Minimum and maximum ages for the analysis were considered to be age group 0 and 3, respectively. Stock weight at age, catch weight at age and maturity ogive was estimated as mean values between 2002 and 2009. Natural mortality vector values were applied per age group using ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Fishing mortalities were the exploitation pattern F in 2009. Reference F was considered to be mean F for ages 0 to 2. Input parameters are shown in the next table.

Table 5.41.5.2.1 YpR input parameters.

age group	stock weight	catch weight	maturity	F	M
0	0.010	0.010	0.5	0.7010	1.17
1	0.014	0.014	0.89	1.3880	0.43
2	0.021	0.021	1	1.0640	0.32
3	0.027	0.027	1	1.0640	0.27

5.41.5.3. Results

Y/R analyses (Figure 5.41.5.3.1) were not considered reliable due to its flat-topped shape. Therefore, $F_{0.1}$ cannot be used as a reference point for this stock. Also, the use of yield-per-recruit analysis for estimating targets for long-term management of pelagic fisheries has been discouraged (Patterson, 1992).

Table 5.41.5.3.1 Resulting parameters from the YpR analysis.

$F_{0.1}$	0.4519
F_{max}	2.0915
F_{ref}	1.0510

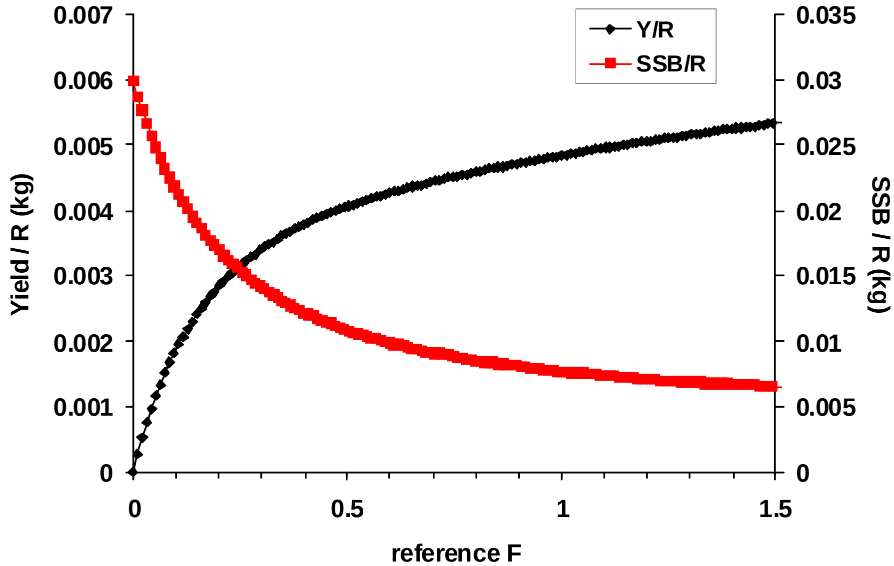


Fig. 5.41.5.3.1 YpR and SSBpR with increasing exploitation F(0-2).

5.41.6. Data quality

No effort data were reported by Spain to SGMED-10-02 through the DCF data call. Thus, SGMED were unable to conduct an analysis of the effort trend for the major fleets fishing anchovy in GSA 01. The ECOMED survey covered the entire GSA 01 only in 2004 and 2005, while the survey did cover only the two most important bays in 2003 and 2006. No data for 2007 was available due to bad weather conditions and lack of time. MEDIAS sampling coverage was incomplete in 2009 due to logistic problems and no data for GSA 01 was available. Inconsistency and data incompleteness in the tuning fleet might affect the assessment results as this is the only tuning fleet available for this assessment.

5.41.7. Scientific advice

It should be noted that small pelagic fishery in GSA 01 is multispecies and effort on anchovy and sardine should be considered together.

Some work was done in SGMED-08-04 and some preliminary reference points were estimated based on yield-per-recruit analysis ($F_{0.1}$ & F_{max}). However the use of yield-per-recruit targets for long-term management of pelagic fisheries has been specifically discouraged (Patterson, 1992) and no reference points can be proposed at this time. Further research is aimed to produce effective Reference Points in this small pelagic fishery as well as Harvest Control Rules.

5.41.7.1. Short term considerations

5.41.7.1.1. State of the spawning stock size

Results of the Extended Survivor Analysis (XSA) analysis indicated a slight increase from the lowest levels observed in 2008. However the anchovy SSB remains at low levels also in 2009.

The state of the spawning biomass in relation to precautionary limits cannot be evaluated since there are no reference points derived due to the short series of data available. It should be considered that this assessment is based on a short time series of data and not suitable to suggest reference points of B_{lim}. Moreover, anchovy is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends also on environmental conditions.

No reference points were proposed for biomass levels, and hence SGMED-10-02 cannot comment on the state of the stock with this respect.

5.41.7.1.2. State of recruitment

XSA model estimates had shown an increase in the number of recruits in 2009, well above the recruitments observed in the last four years (2005-2008) and similar to the recruitments occurred in 2003 and 2004. The trend of the recruitments is important as small pelagic stocks and fisheries are highly dependent of the recruitment strength. SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the short time series available.

5.41.7.1.3. State of exploitation

Based on XSA results, the mean F (for ages 0 to 2) increased since 2003.

The exploitation rate during the last five years (E=0.6) is above the exploitation reference points (E=0.4) proposed by Patterson (1992) and suggested by SGMED as an appropriate limit management reference point consistent with high long term yields for small pelagics.

Based on this assessment results the stock is considered overexploited. However, SGMED stresses that the use of the exploitation rate is very sensitive to M values.

The management of the anchovy fisheries in GSA 01 needs to account for multi-species effects, mainly the interaction with sardine.

5.42. Stock assessment of anchovy in GSA 06

5.42.1. Stock identification and biological features

5.42.1.1. Stock Identification

The assessment of small pelagic stocks in the Mediterranean is conducted by Geographical Sub-Areas (GSAs) as defined in the GFCM framework. Little or no specific work has been carried out on the stock identification of small pelagic species in the Mediterranean and further analysis is needed to evaluate the small pelagic fish stock complex in the area.

The attached figure shows the GFCM Geographical Sub- Area GSA 06, showing all landings ports. Sampled ports are highlighted in blue.

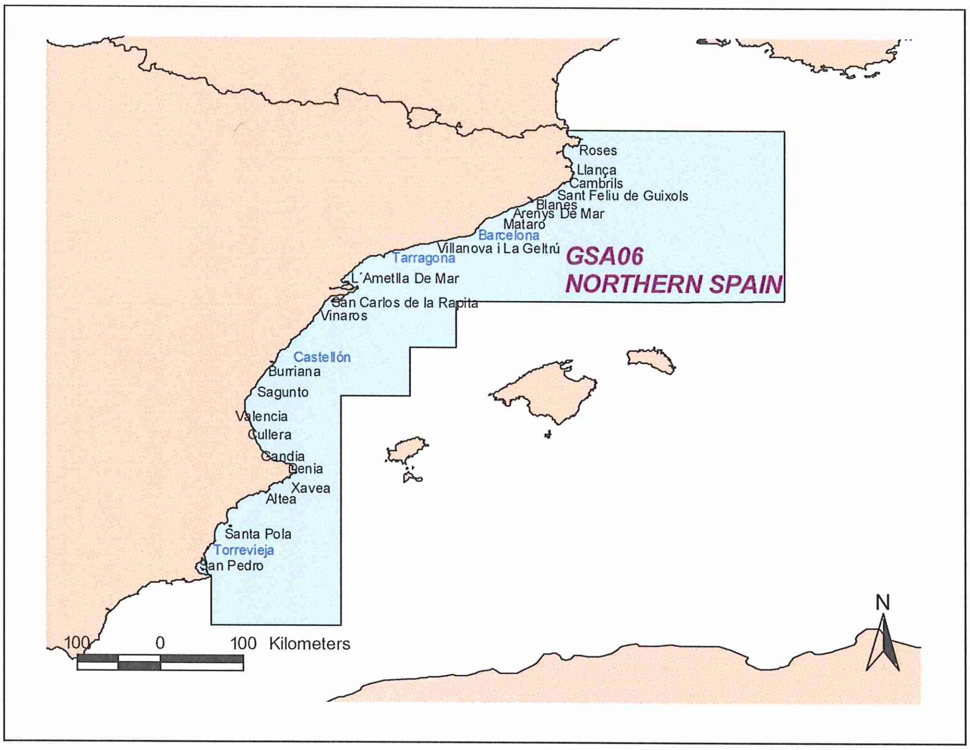


Fig. 5.42.1.1.1 Stock distribution area.

5.42.1.2. Growth

Growth parameters were estimated throughout the DCR biological sampling on a triennial basis (Table 5.42.1.2.1). The growth parameters were derived from anchovy in GSA 01. The used method was the Von Bertalanffy growth equation fit using age (obtained through otolith readings) and length data using non-linear estimation with minimum least squares (Gauss-Newton algorithm) and Bootstrapped precision estimates.

Table 5.42.1.2.1 Growth parameters.

PERIOD	L8	k	t0	a	b
2002-2004	19.0	0.3395	-1.8815	0.0029	3.3171
2005-2008	19.0	0.3419	-2.3210	0.0040	3.1945
2008-2009	19.0	0.4337	-1.8801	0.0033	3.2761

5.42.1.3. Maturity

Maturity at age was estimated throughout the DCR biological sampling from years 2004-2007. These values were considered constant through the years of the assessed time series (1994-2007).

Tab. 5.42.1.3.1 Maturity ogive.

Age	0	1	2	3
Prop. Matures	0.50	0.89	1.00	1.00

5.42.2. Fisheries

5.42.2.1. General description of fisheries

The most updated fleet information corresponds to GFCM WG 2009, containing data up to 2008. The purse seine fleet operating in GSA 06 is composed by 130 units: 4% are smaller than 12 m in length, 87% between 12 and 24 m and 9% larger than 24 m. The fleet continuously decreased in the last decade, from more than 222 vessels in 1995 to 130 in 2008. This strong reduction (59%) is possibly linked to a continuous decline of small pelagic catches.

Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are the main target species of the purse seine fleet in GSA 06, but other species with lower economical importance are also captured, sometimes representing a high percentage of the capture as horse mackerel (*Trachurus* spp.), mackerel (*Scomber* spp.) and gilt sardine (*Sardinella aurita*).

5.42.2.2. Management regulations applicable in 2009 and 2010

- Fishing license.
- Minimum landing size 11 cm.
- No fishing allowed on weekend. Time at sea 12 hours per day and 5 days a week: fully observed.
- Several technical measures regulations (gear and mesh size, engine, GRT, etc.).
- Temporary fishing closures (From 1st December to 31st January).

5.42.2.3. Catches

5.42.2.3.1. Landings

The annual landings of anchovy (*Engraulis encrasicolus*) in GSA 06 for the last seven years ranged between 14,338 and 2,570 t (Table 5.42.2.3.1.1). This species is the most valuable species in the pelagic fisheries of GSA 06.

Landings in 2009 were 9,814 t, showing a large increase from 2008 (2,558 t). Apart from this recent 2009 increase, the time series shows a very sharp decrease from the beginning of the times series in 2002. The lowest values of the assessed time series were reported in 2008.

Tab. 5.42.2.3.1.1 Annual landings (t) by fishing technique (purse seiners) in GSA 06.

Year	2002	2003	2004	2005	2006	2007	2008	2009
Catch (t)	14338	8538	8097	6216	3096	2570	2558	9814

5.42.2.3.2. Discards

Discards of anchovy in GSA 06 are considered negliglible. Only in 2004 17 t were reported to SGMED-10-02 through the DCF official data call.

5.42.2.3.3. Fishing effort

No effort data were reported by Spain to SGMED-10-02 through the DCF official data call. Thus, SGMED was unable to conduct an analysis of the effort trend for the major fleets fishing anchovy in GSA 06.

5.42.3. Scientific surveys

5.42.3.1. ECOMED and MEDIAS acoustic surveys

ECOMED was carried out data from 1990 to 2008, although the abundance time series used for XSA tuning is from 2003-2008. ECOMED is carried out in winter season, targeting mainly the spawning period of sardine. MEDIAS, a new pan-mediterranean acoustic survey started in 2009 and it is carried out during the summer, targeting mainly the spawning period of anchovy.

5.42.3.1.1. Methods

The sampling coverage is complete for all analysed years in GSA 06 for both acoustic surveys.

ECOMED Surveys were carried out on board the R/V Cornide de Saavedra during late autumn (November-December). MEDIAS surveys were carried out on board the R/V Cornide de Saavedra during early summer (June-July). A multifrequency echosounder was utilised (SIMRAD-ER60), sampling at frequencies of 38 kHz, 70 kHz, 120 kHz and 200 kHz. The ESDU is 1 nm. The pulse duration is 1 msg. The software used for echogram identification is *SonarData Ecoview*.

During ECOMED, the sampling grid is constituted by parallel tracks, perpendicular to the coast. Acoustic sampling is performed during daytime. Experimental fishing with pelagic trawl for schools identification was done at night in the previously tracked positions.

MEDIAS used the same vessel, the same echosounder and the same sampling grid with ECOMED but experimental fishing with pelagic trawl for schools identification was done during the day.

5.42.3.1.2. Geographical distribution patterns

The studied area is usually split in two regions, the Tramontana Region (from Cape Creus to Cape La Nao) and Levantine Region (from Cape La Nao to Cape Palos). The time period (November – December) when the ECOMED survey is conducted corresponds to the recruitment season of the anchovy and spawning season of sardine. Hence the acoustic survey provides an estimation of the recruitment of the anchovy. They are two recruitment areas: one located between Barcelona and the south of the Ebro River Delta (the most important) and other in Rosas Bay.

5.42.3.1.3. Trends in abundance and biomass

According to survey estimates, 2008 showed the largest abundance of anchovy. This data is in agreement with the large catched reported in 2009 (from 2558 in 2008 to 9814 in 2009). It should have to note that data from 2008 and 2009 and not directly comparable as they are different acoustic surveys in different seasons and also different methodology of fishing (ECOMED at night and MEDIAS at daytime).

Table 5.42.3.1.3.1 Estimated survey abundance and biomass values.

SPECIES	SURVEY	YEAR	2003	2004	2005	2006	2007	2008
ANE	ECOMED	Number (mill)	3884	1993	859	1532	971	6548
		Biomass (t)	23415	14627	8170	12669	4906	30533

SPECIES	SURVEY	YEAR	2009
ANE	MEDIAS	Number (mill)	2850
		Biomass (t)	28090

5.42.3.1.4. Trends in abundance by length or age

Table 5.42.3.1.4.1 Abundance at length derived from ECOMED surveys.

ECOMED		SPECIES	ANE			
	YEAR					
LENGTH_CLASS	2003	2004	2005	2006	2007	2008
3.5	0	0	0	0	0	0
4	0	0	0	0	581	0
4.5	0	0	0	0	0	0
5	0	0	0	0	1744	6402
5.5	557	2107	0	0	934	19147
6	371	2974	236	0	4535	19147
6.5	1571	13655	337	0	9665	54675
7	2498	28839	236	0	27962	323264
7.5	36083	67883	3517	746	60516	533438
8	189599	96941	4868	5077	119142	824896
8.5	449685	153346	16254	28504	150633	815499
9	611525	248790	86481	112145	150480	852487
9.5	597220	211766	89242	278520	176357	966934
10	638018	236475	88441	181429	112959	941564
10.5	527223	224480	78195	170856	61143	610102
11	363023	190542	88199	219040	41279	338792
11.5	213662	121924	83871	203420	10609	109164
12	130891	99126	63596	118198	10902	81934
12.5	35513	76137	49551	65633	5859	11500
13	18777	51190	53640	45226	3816	17909
13.5	29823	38497	39870	17471	1503	16924
14	11496	48966	33241	23326	3189	2711
14.5	16385	32385	27726	14229	3679	0
15	4936	27726	22437	16856	6737	923
15.5	4889	10491	17678	11234	5259	0
16	46	6341	8467	9288	1092	0
16.5	0	1974	2957	2088	742	923
17	0	0	270	6586	0	0
17.5	0	0	0	1544	0	0
18	0	0	0	338	0	0
18.5	0	0	0	0	0	0

Table 5.42.3.1.4.2 Abundance at length derived from the MEDIAS survey.

MEDIAS	SPECIES	ANE
		YEAR
	LENGTH_CLASS	2009
	3.5	0
	4	0
	4.5	0
	5	0
	5.5	330
	6	0
	6.5	0
	7	5773
	7.5	29577
	8	90990
	8.5	134951
	9	108160
	9.5	156028
	10	242246
	10.5	308815
	11	401962
	11.5	381553
	12	278716
	12.5	284931
	13	174213
	13.5	138742
	14	52454
	14.5	41701
	15	15006
	15.5	2253
	16	953
	16.5	74
	17	74
	17.5	0
	18	0

5.42.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.42.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.42.4. Assessment of historic stock parameters

5.42.4.1. Method 1: Separable VPA and XSA

5.42.4.1.1. Justification

This assessment is based on VPA (XSA) methods, tuned by acoustic surveys (see previous section). A separable VPA was also run as an exploratory analysis.

5.42.4.1.2. Input parameters

Data used for XSA:

- Landings from 2002-2009 from GSA 06 (DCF official data).
- Combined ALK (2003-2009) for all the years (DCF official data).
- Length distributions 2003-2009 (DCF official data). For 2003, length distributions estimated in 2002 were applied.
- Biological sampling 2003-2009 for Maturity at Age and Weight-Length relationships (DCF official data).
- Tuning data from acoustic surveys ECOMED 2003-2008 (DCF official data).

Input data for the assessment model are the following.

Table 5.42.4.1.2.1 Landings (t) 2002-2009.

Year	2002	2003	2004	2005	2006	2007	2008	2009
Catch (t)	14338	8538	8097	6216	3096	2570	2558	9814

Table 5.42.4.1.2.2 Catch numbers at age 2003-2009 (thousands).

Catch in numbers (thousands)			
1 2002 0 1	2 2009 3		
265224	352327	175977	10193
157936	209804	104791	6070
171698	202604	95310	4567
58810	114984	101970	10121
59829	73228	37189	3016
20649	41920	42399	6262
71575	61632	27343	1454
130223	217643	141683	7875

Table 5.42.4.1.2.3 Catch and stock weight at age (kg), 2003-2009.

Mean Weight in Catch (kilograms)			
1	3		
2002	2009		
0	3		
1			
0.014	0.018	0.022	0.027
0.014	0.018	0.022	0.027
0.013	0.018	0.022	0.026
0.017	0.021	0.025	0.029
0.014	0.018	0.023	0.03
0.018	0.021	0.027	0.031
0.012	0.017	0.021	0.027
0.016	0.02	0.023	0.026

Table 5.42.4.1.2.4 Tuning data from ECOMED surveys 2003-2008 and 2009 (MEDIAS).

Anchovy GSA06 - survey (thousands) and fleet (thousands and days by 100HP)				
102				
FLT01-ECOMED (thousands)				
2003	2009			
1	1	0.88	0.93	
0	3			
1	3778218	58677	0	0
1	1777202	92036	0	0
1	700493	40034	0	0
1	1461320	37761	646	0
1	963351	7384	0	0
1	5962287	9207	0	0
0	0	0	0	0
FLT02-MEDIAS (thousands)				
2003	2009			
1	1	0.45	0.53	
0	3			
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	1995431	648557	91559	1586

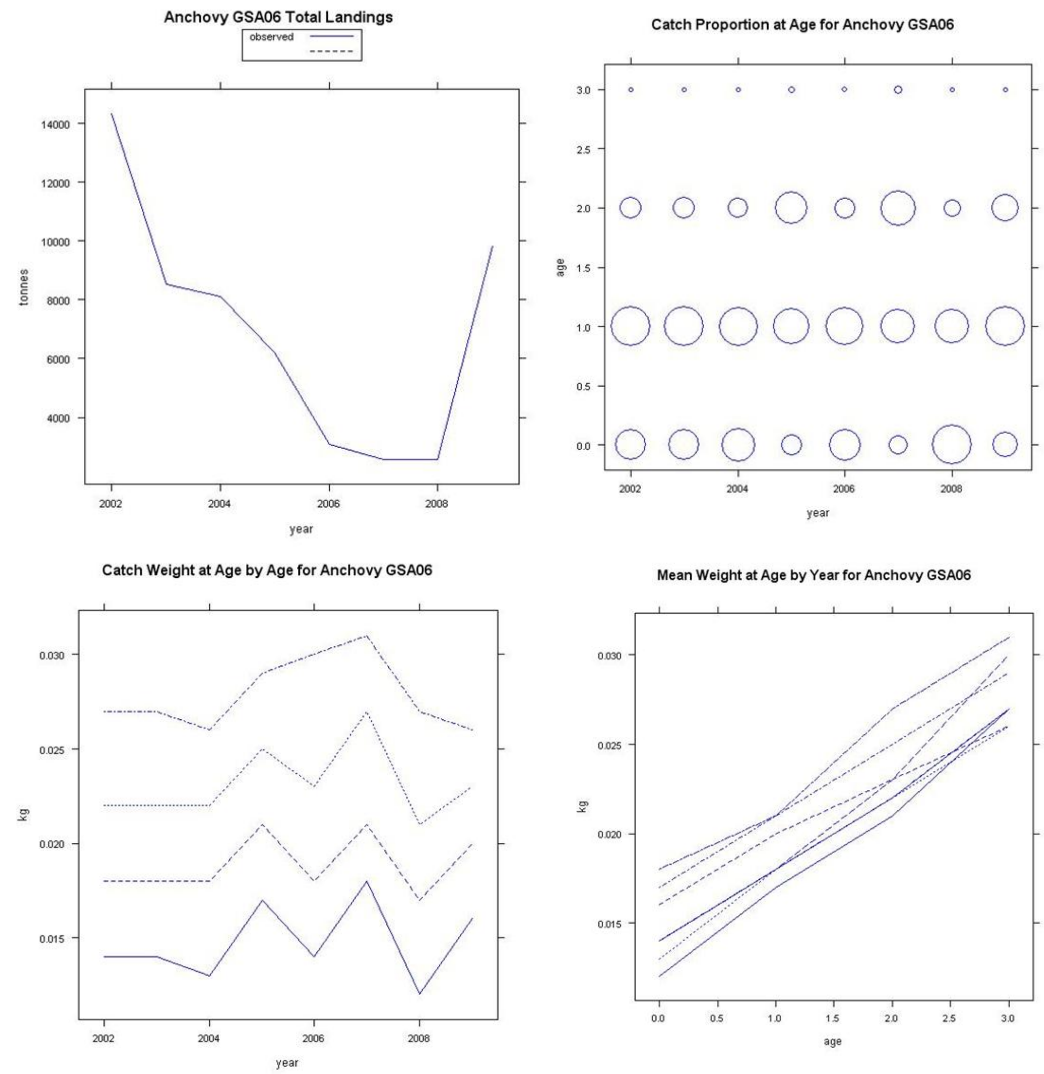


Fig. 5.42.4.1.2.1 Illustration of input parameters.

Table 5.42.4.1.2.5 Further input parameters to the assessment models.

Input Parameters GSA06

- **Growth Parameters:**

  Linf = 19   k = 0.4237 t_0 = -1.88

- **Length-weight relationship:**

  a = 0.0033   b = 3.27

- **Natural Mortality Vector PRODBIOM (Abella *et al.*1997):**

Age	0	1	2	3	Mean(0-3)	Mean(0-2)
M	1.17	0.43	0.32	0.27	0.55	0.64

- **Maturity at Age**

Age	0	1	2	3
PropMat	0.50	0.89	1.00	1.00

5.42.4.1.3. Results including sensitivity analyses

A separable VPA was run as exploratory analysis. Log catchability residual plots shows large residuals and difference between ages. These patterns are likely due to huge catch numbers in year 2009. The separable plot can be seen in the attached figure.

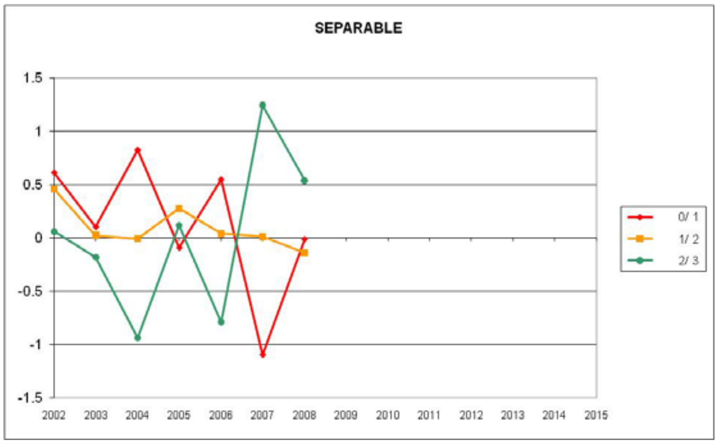


Fig. 5.42.4.1.3.1 Log catchability residual plots from the separable VPA.

Successively, a XSA assessment was run. The main settings for the XSA were the following:

- Fbar 0-2.
- Age 1 for q stock-size independent and age 2 for q independent of age.
- Fshrinkage = 0.500 and S.E. for fleet terminal estimates ≥ 0.300

XSA Diagnostics in the form of residuals by fleet are shown in figure . 5.42.4.1.3.2 and did not show any particular trend.

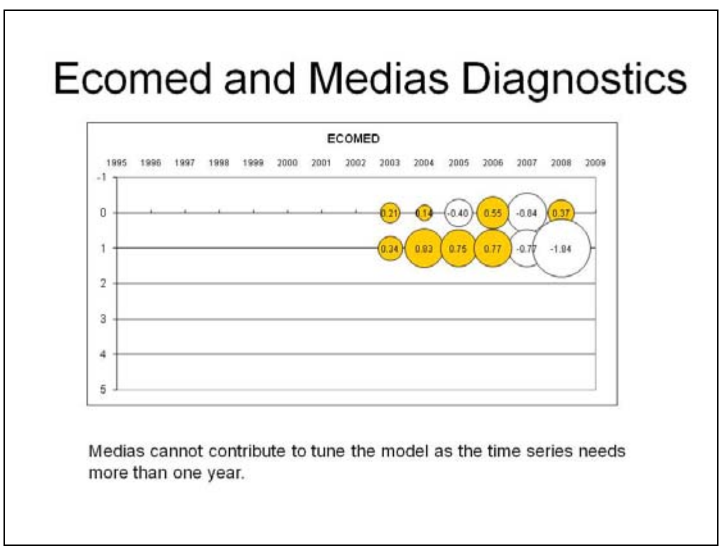


Fig. 5.42.4.1.3.2 Log catchability residual plots from the XSA.

Estimations of survivors by age and tuning fleet were produced. The most important weights are given by the Fshrinkage.

Fig. 5.42.4.1.3.3 Tuning diagnostics derived from XSA.

Tab. 5.42.4.1.3.1 Estimated fishing mortalities at age, 2002-2009.

Fishing mortality (F) at age								
YEAR	2002	2003	2004	2005	2006	2007	2008	2009
AGE								
0	0.2754	0.1789	0.341	0.1692	0.2228	0.03	0.0653	0.1853
1	1.1363	0.8166	0.8197	0.9303	0.715	0.493	0.2256	0.6105
2	2.7673	2.4693	1.7998	2.6576	1.2819	2.1179	0.9282	1.8743
3	1.418	1.1744	1.0024	1.2732	0.7484	0.8886	0.4108	0.8962
FBAR 0-2	1.393	1.15493333	0.98683333	1.25236667	0.7399	0.8803	0.40636667	0.89003333

Tab. 5.42.4.1.3.2 Estimated stock size at age (thousands), 2002-2010.

Table 10	Stock number at age (start of year)			Numbers*10**-3					
YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE									
0	1977917	1730245	1066728	678233	537656	1256093	2031213	1381797	0
1	643360	466122	449024	235423	177738	133540	378346	590547	356315
2	220357	134345	134001	128686	60405	56559	53058	196409	208617
3	15395	10054	8258	16087	6552	12173	4940	15228	21888

Tab. 5.42.4.1.3.3 XSA results, stock summary table without SOP correction.

Summary (without SOP correction)						
	Terminal Fs derived using XSA (With F shrinkage)					
	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 0- 2
	Age 0					
2002	1977917	44535	29416	14338	0.4874	1.393
2003	1730245	35841	22806	8538	0.3744	1.155
2004	1066728	25113	17290	8097	0.4683	0.987
2005	678233	20158	13849	6216	0.4489	1.252
2006	537656	12312	8197	3096	0.3777	0.740
2007	1256093	27318	15705	2570	0.1636	0.880
2008	2031213	32054	19159	2558	0.1335	0.406
2009	1381797	38833	26479	9814	0.3706	0.890
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Figure 5.42.4.1.3.4 show the summary results from the XSA, i.e. Total Landings, Fishing Mortality (F_{bar} 0-2), Recruitment in number, Total Biomass and Spawning Stock Biomass (SSB).

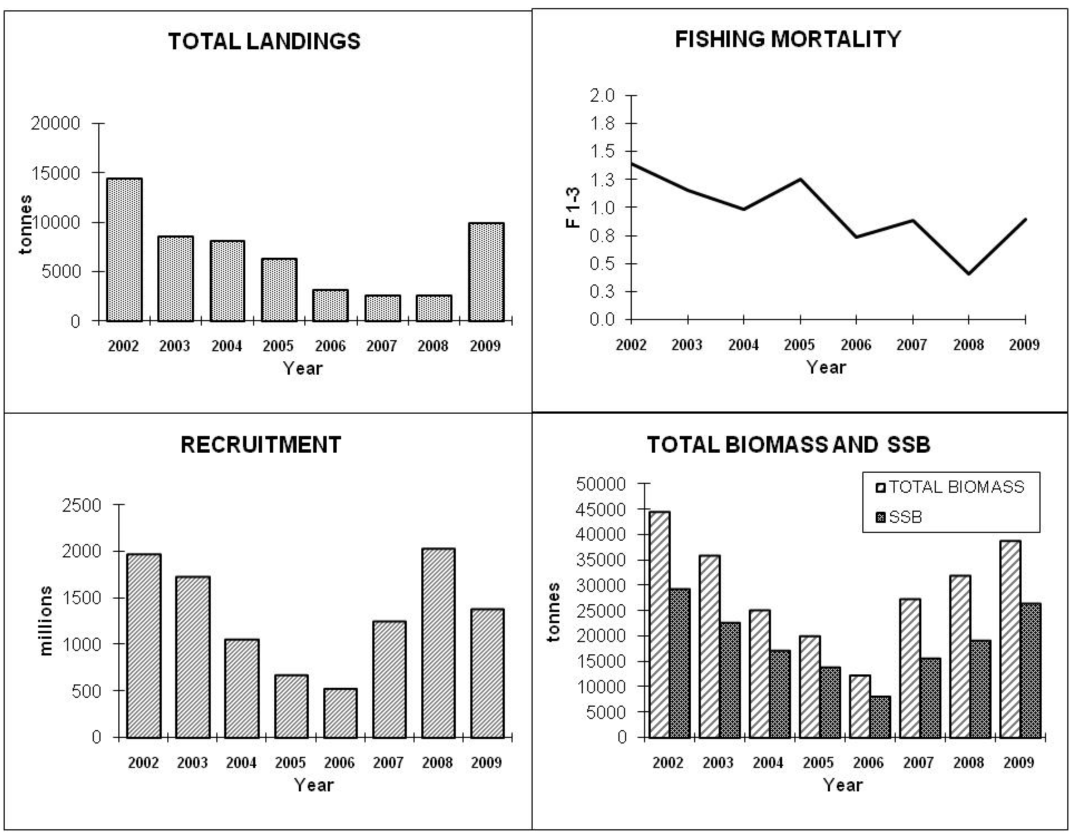


Fig. 5.42.4.1.3.4 Resulting XSA stock parameters.

Fishing mortality has generally decreased during the time series. However, F in 2009 was slightly larger than 2008. F_{0-2} in 2009 was 0.89. Recruitment in 2009 (1380 millions) decreases compared to 2008 (2030 millions) and generally seems to follow the trend in SSB. Both Total Biomass (38,830 t) and Spawning Stock Biomass in 2009 (26,480 t) increased from the lowest value observed in 2006. The annual exploitation rate E = F/(F+M) or F/Z was also calculated and plotted over the years. The constant M value (0.64) was estimated as the mean of the 0-2 ages of the M vector. The values obtained were compared with the threshold F/Z = 0.4 adopted as biological reference point for small pelagics (Patterson, 1992) by SGMED. The values of F/Z were plotted over years in figure 5.42.4.1.3.5:

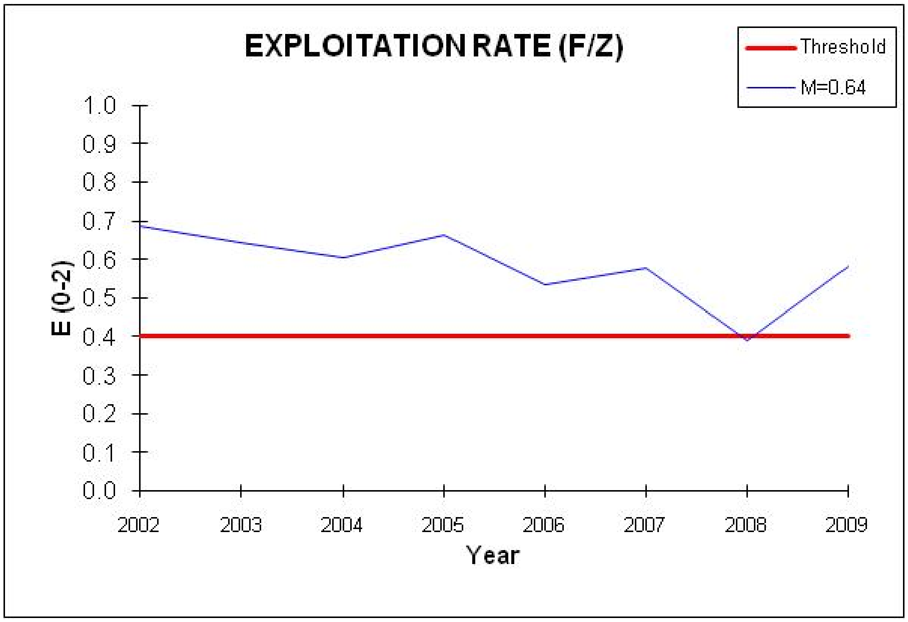


Fig. 5.42.4.1.3.5 The values of E=F/Z plotted over years and compared to the reference level of E=0.4.

5.42.5. Long term prediction

5.42.5.1. Justification

Yield-per-recruit analysis was carried out during SGMED-10-02. Yield per recruit analyses was conducted based on the exploitation pattern resulting from the XSA model and population parameters.

5.42.5.2. Input parameters

Minimum and maximum ages for the analysis were considered to be age group 0 and 3, respectively. Stock weight at age, catch weight at age and maturity ogive was estimated as mean values between 2002 and 2009. Natural mortality vector values were applied per age group using ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Fishing mortalities were estimated as average of 2002-2009. Reference F was considered to be mean F for ages 0 to 2. Input parameters are shown in the table 5.42.5.2.1.

Table 5.42.5.2.1. YpR Input parameters.

	age group	**stock weight**	**catch weight**	**maturity**	**F**	**M**
age min = 0	0	0.015	0.015	0.5	0.18	1.17
age max = 3	1	0.019	0.019	0.89	0.71	0.43
	2	0.023	0.023	1	1.98	0.32
Fref = 0.72	3	0.028	0.028	1	0.97	0.27

5.42.5.3. Results

Y/R analyses (Fig. 5.42.5.3.1) were not considered reliable due to its flat-topped shape. Therefore, $F_{0.1}$ cannot be used as a reference point for this stock. Also, the use of yield-per-recruit analysis for estimating targets for long-term management of pelagic fisheries has been discouraged (Patterson, 1992).

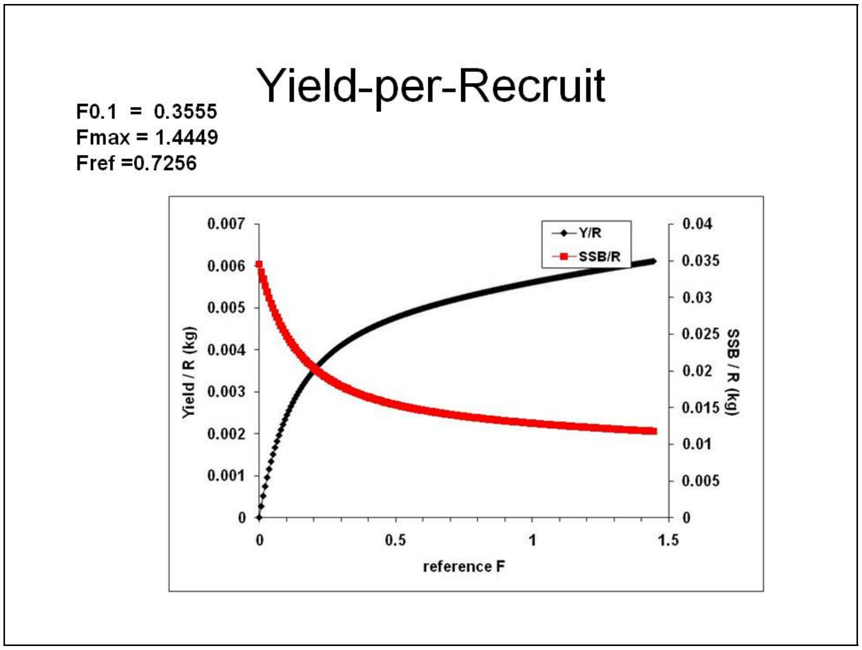


Figure 5.42.5.3.1 YPR analysis for anchovy in GSA 06.

5.42.6. Data quality and availability

No effort data were reported by Spain to SGMED-10-02 through the DCF data call. Thus, SGMED were unable to conduct an analysis of the effort trend for the major fleets fishing anchovy in GSA 06.

5.42.7. Scientific advice

5.42.7.1. Short term considerations

5.42.7.1.1. State of the spawning stock size

Both total biomass (38,830 t) and spawning stock biomass in 2009 (26,480 t) increased from the lowest value observed in 2006. No precautionary management reference points were proposed for biomass levels, and hence SGMED cannot comment on the state of the stock with this respect.

5.42.7.1.2. State of recruitment

Recruitment in 2009 (1380 millions) decreases compared to 2008 (2030 millions) and generally seems to follow the trend in SSB. SGMED highlighted that the stock and the fishery is highly dependent on the recruitment strength.

5.42.7.1.3. State of exploitation

Fishing mortality has generally decreased during the time series. However, F in 2009 was slightly larger than 2008. F_{0-2} in 2009 was 0.89.

The exploitation rate during the last five years (E=0.6, with the exception of 2008) is above the exploitation reference points (E=0.4) proposed by Patterson (1992) and suggested by SGMED as an appropriate management reference point consistent with high long term yield for small pelagics.

Based on this assessment results the stock is considered overexploited. However, SGMED stresses that the use of the exploitation rate is very sensitive to M values. It is important to stress that the fishery for small pelagics in GSA 06 is a multispecies fisheries and effort on anchovy and sardine should be considered together.

5.43. Stock assessment of anchovy in GSA 09

5.43.1. Stock identification and biological features

5.43.1.1. Stock Identification

Due to a lack of information about the structure of anchovy population in the western Mediterranean, this stock was assumed to be confined within the GSA 09 boundaries. Studies are needed on the biological stock identification of this species in the Mediterranean. The spawning season of the species in the area is in spring-summer. The maximum age recorded was 5 years while the maximum length was 17.5 cm TL.

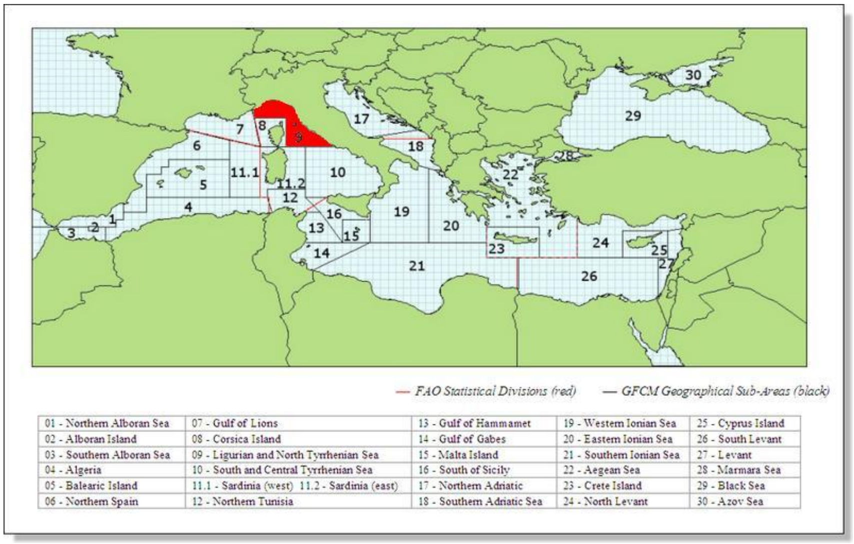


Fig. 5.43.1.1.1 Stock distribution map.

5.43.1.2. Growth

Growth parameters were estimated using data collected in the framework of the DCF. The method applied was the Von Bertalanffy equation fit to the age (otolith readings) and growth data using non-linear estimation with minimum least squares. An example of age-length key expressed in number of individuals, obtained through DCF for the commercial catches of purse seiners in 2008, was reported in Tab 5.43.1.2.1.

Tab 5.43.1.2.1 GSA 9 anchovy: age-length key (year 2008, purse seiners).

	Age group				
TL (cm)	0	1	2	3+	Total
10.5	9				9
11.0	30	26			56
11.5	11	250			261
12.0		621			621
12.5		650	84		734
13.0		688	220		908
13.5		482	432		914
14.0		217	766	6	989
14.5		102	642	24	768
15.0		6	518	59	583
15.5			286	103	389
16.0			155	79	234
16.5			41	44	85
17.0			5	8	13
17.5				2	2
Total	50	3042	3149	325	6566

5.43.1.3. Maturity

The first sexual maturity for female anchovy in the GSA 9, estimated using collected in the framework of DCF, is around 11.6 cm TL.

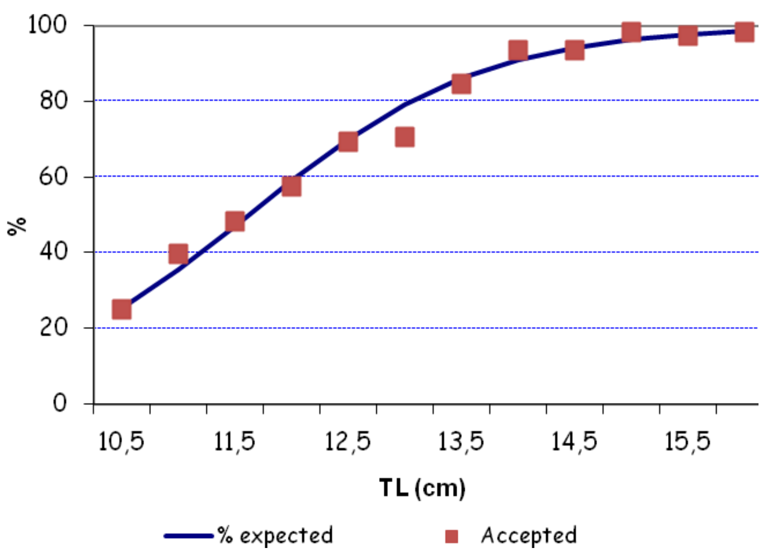


Fig. 5.43.1.3.1 GSA 09 anchovy: size at first maturity.

5.43.2. Fisheries

5.43.2.1. General description of the fisheries

In the GSA 09, anchovy is mainly exploited by purse seiners that use light for attracting fish. Due to the high economic value, anchovy represents the target species for this fleet in the GSA 09 while sardine (*Sardina* *pilchardus*) is the other important species exploited by this fishery. The fishing season starts in spring (March) and ends in autumn (October). Favorable weather conditions and abundance in the catches can extend the fishing activity to the end of November. However, the maximum activity of the fleet is normally observed in summer. Some vessels coming from the south of Italy (mainly from GSA 10) join the local fleet. Anchovy is also a by-catch in the bottom trawl fishery; however, the landing done by this *metier* is negligible in comparison to that of purse seine. Pelagic trawling is not carried out in the GSA 09.

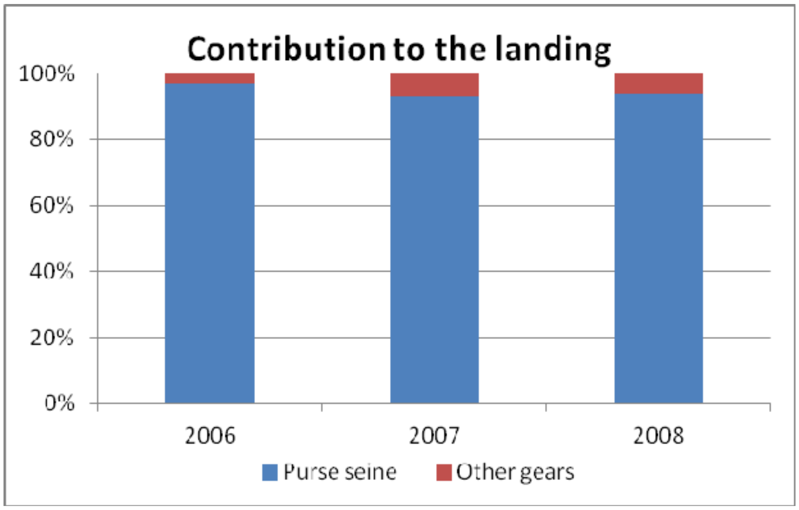


Fig. 5.43.2.1.1 GSA 09 anchovy: Contribution of the different fleets to the total landing in the period 2006-2008.

5.43.2.2. Management regulations applicable in 2009 and 2010

In Italy, the legal minimum length for anchovy is 9 cm (R. (CE) 1967/2006). 14 mm is the minimum mesh size allowed for purse seine and 40 mm squared or 50 mm diamond cod end mesh size for bottom trawl.

5.43.2.3. Catches

5.43.2.3.1. Landings

The annual amount of the total catch of anchovy reported by the Italian national statistics for GSA 09 is plotted in Fig. 5.43.2.3.1.1. An increasing trend is observed from 1961 to 1986 with two evident peaks in 1976 and 1986. Then, a strong decrease occurred, with minimum values registered in 1991-92. In the last 20 years the landings resulted notably lower than those observed in the previous period, with very low values in the last two years (2007 and 2008).

A comparison between the landing data and the MEDITS biomass index (kg/km^2) for the period 1994-2008 showed a significant correspondence of the two trends. This fact could be considered as a sort of cross-validation of the two data series recognizing MEDITS as a possible indicator of the trend of the biomass also for small pelagic species like anchovy. In the GSA 09 specific studies on the abundance of small pelagic species started only in 2009 (MEDIAS survey).

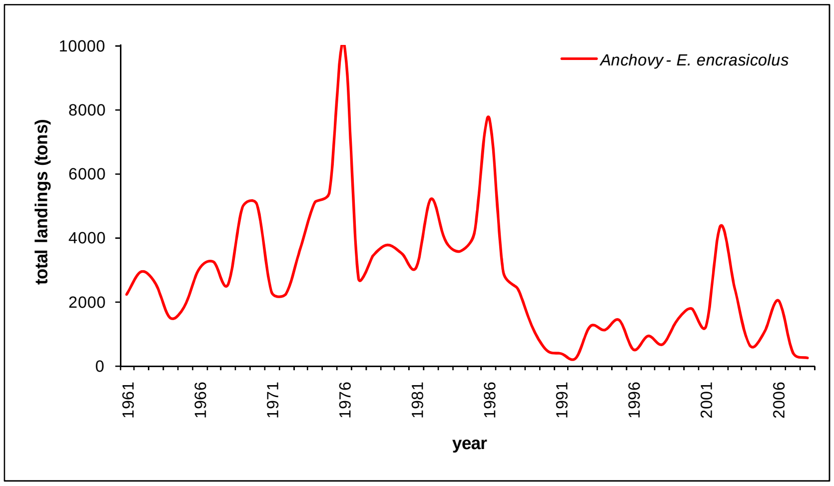


Fig. 5.43.2.3.1.1 GSA 9 anchovy: total catch over years.

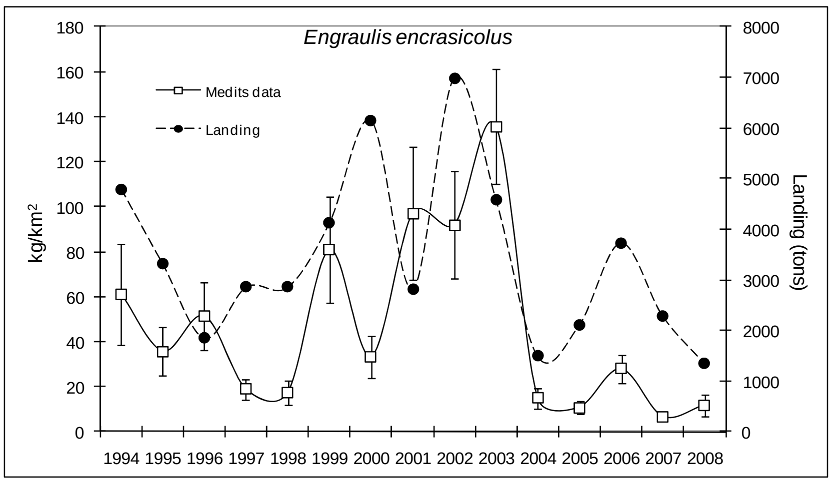


Fig. 5.43.2.3.1.2 GSA 09 anchovy: comparison of the total landing with the MEDITS biomass indices for the period 1994-2008.

Data on size and age composition of the landing in the GSA 09 are available for the period 2006-2008. The length frequency distribution and the age frequency distribution of the purse seine landing are shown in Figures 5.43.2.3.1.3. and 5.43.2.3.1.4. In both cases, the distribution observed in 2007 resulted quite different from the other two years. In 2007 the modal class was at 11.5 cm TL, corresponding to the specimens in the first age class (0+). In 2006 and 2008 the modal class was at 12.5-13 and 14 cm TL respectively; and thus in both years the main important age class was 1+.

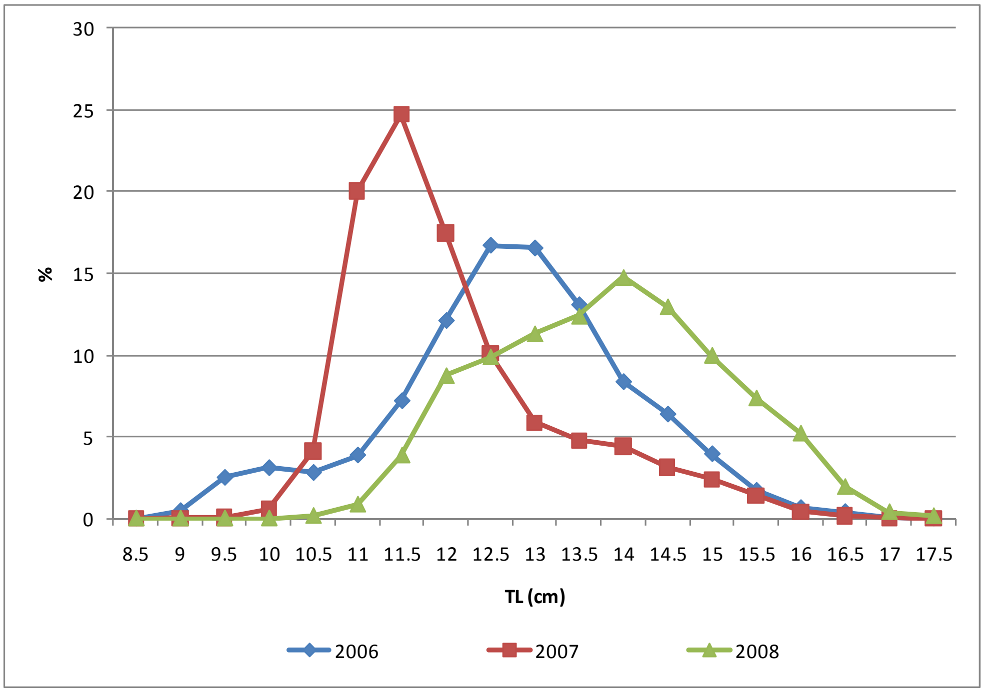


Fig. 5.43.2.3.1.3 GSA 09 anchovy: annual length frequency distribution of the purse seine landing.

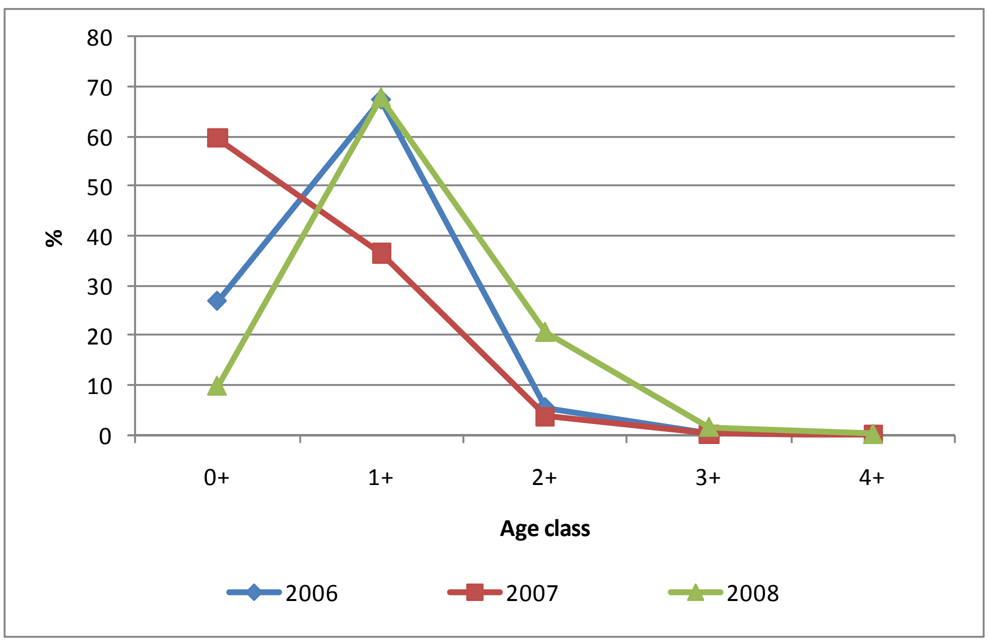


Fig. 5.43.2.3.1.4 GSA 09 anchovy: annual age frequency distribution of the purse seine landing.

Tab. 5.43.2.3.1.1 Landings (t) as officially submitted through the DCF data call. No data for 2009 were reported by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
ANE	9	ITA						0	5				
ANE	9	ITA	GNS	DEMSP				2	25	13	16	18	
ANE	9	ITA	GNS	SLPF					2			4	
ANE	9	ITA	LLD	LPF						3			
ANE	9	ITA	OTB	DEMSP				26	2	3	15	81	
ANE	9	ITA	OTB	MDDWSP				33	118	78	69	10	
ANE	9	ITA	PS	LPF								2	
ANE	9	ITA	PS	SPF				1432	1956	3630	2193	1240	

5.43.2.3.2. Discards

Studies carried out in the framework of the DCF in 2005 demonstrated that discards of anchovy for the Italian fleet can be considered as negligible because anchovy, usually, is strongly required by the market. According to the DCF investigation, the discard at sea of anchovy amounted 65 t and 206 t in the third and fourth quarter of 2005, respectively. These quantities were very low in comparison with the corresponding landings, 20,000 t on average per year in the period 2000-2007. The estimates of discards obtained for one half of 2005 was considered negligible and have been not included in the estimation of total catches.

5.43.2.3.3. Fishing effort

The fishing capacity of the purse seine fleet in the GSA 09 showed in these last 9 years a progressive increase in the period 2002-2004, passing from about 33-35 vessels to 52. Then, the number of vessels remained constant over time.

The activity mainly ranged between 4,500 and 5,200 fishing days per year, with maximum value in 2004 (7,256) and minimum in the last year (3,911). The fishing effort, expressed as kW·fishing days, shows higher values since 2004.

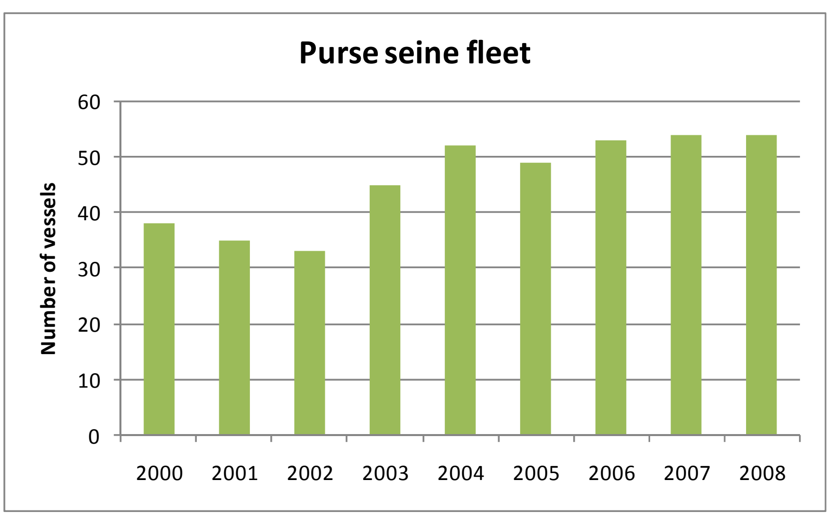


Fig. 5.43.2.3.3.1 GSA 09: Number of purse seine vessels for the period 2000-2008.

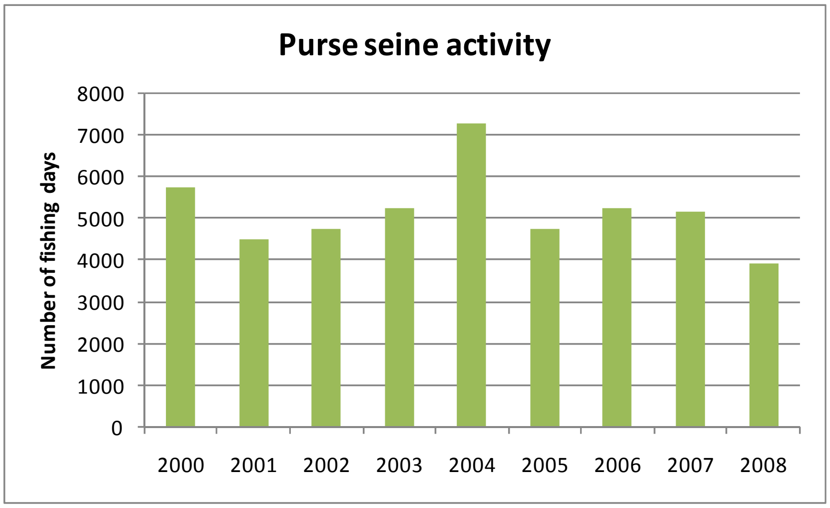


Fig. 5.43.2.3.3.2 GSA 09: Number of purse seine fishing days per year.

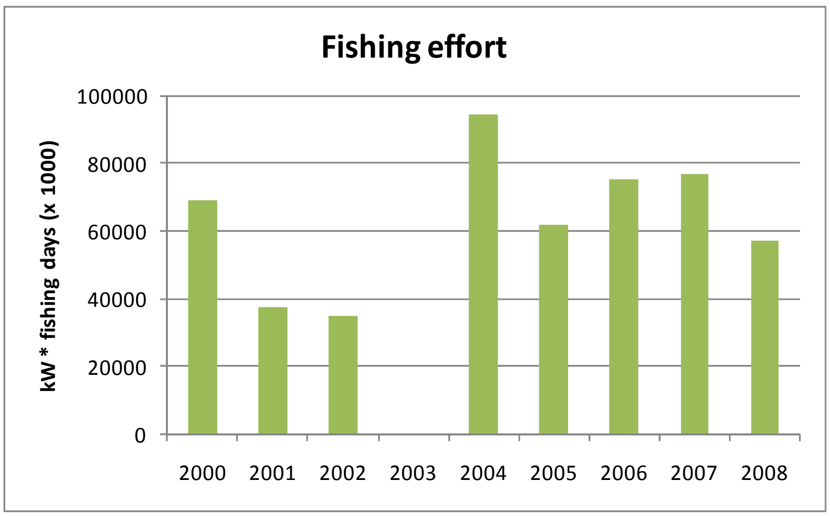


Fig. 5.43.2.3.3.3 GSA 09: total fishing effort (KW*days) of purse seine vessels.

Tab. 5.43.2.3.3.1 Fishing effort (kW*days at sea) as submitted through the DCF data call. No effort data were reported for 2009 by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
9	ITA				VL0006					296		
9	ITA				VL0612		31025	45782	71302	4865	12129	
9	ITA	DRB	MOL		VL1218		18652	20370	13504	29808	28266	
9	ITA	GNS	DEMSP		VL0006				14365	9687	7681	
9	ITA	GNS	DEMSP		VL0612		204925	219978	146971	201390	146006	
9	ITA	GNS	DEMSP		VL1218		100498	59006	49194	62666	67944	
9	ITA	GNS	SLPF		VL0612		4857				3707	
9	ITA	GTR	DEMSP		VL0006				1417	4451		
9	ITA	GTR	DEMSP		VL0612		75571	121141	100767	142363	43116	
9	ITA	GTR	DEMSP		VL1218		3222	19168	11102	14510	6610	
9	ITA	LLD	LPF		VL0612		6569	17394	3581	5904	25890	
9	ITA	LLD	LPF		VL1218		1611	4427	24956	5535	12094	
9	ITA	LLS	DEMF		VL0612		37454	75215	18823	4330		
9	ITA	LLS	DEMF		VL1218		3914	9998				
9	ITA	LTL	LPF		VL0006				3198	687		
9	ITA	OTB	DEMSP		VL0612		7282	6524	15126	21176	14595	
9	ITA	OTB	DEMSP		VL1218		118419	113284	77407	171295	221969	
9	ITA	OTB	DEMSP		VL1824		515183		69690	200680	478813	
9	ITA	OTB	DEMSP		VL2440		125282					
9	ITA	OTB	MDDWSP		VL1218		151739	183842	177083	158561	57869	
9	ITA	OTB	MDDWSP		VL1824		85625	737780	692516	404814	75728	
9	ITA	PS	SPF		VL0612			10014				
9	ITA	PS	SPF		VL1218			3703				
9	ITA	PS	SPF		VL1824		6526	6055				
9	ITA	SB-SV	DEMSP		VL0006				3780	3664	4506	
9	ITA	SB-SV	DEMSP		VL0612		127810	191056	133213	74903	62000	
9	ITA	SB-SV	DEMSP		VL1218		22438	10582	13566	2988	5196	

5.43.3. Scientific surveys

As mentioned above, in GSA 09 MEDIAS survey started in 2009. In the future, the data collected through this eco-survey will be utilized for tuning the VPA.

5.43.4. Assessment of historic stock parameters

5.43.4.1. Method: LCA on DCR data

5.43.4.1.1. Justification

Assessment was performed using an LCA (VIT software, Lleonart and Salat 1997) on an annual pseudo-cohort. Data coming from DCR provided at SGMED 10-02 contained, for GSA 09, information on anchovy landings and the respective size/age structure for the years 2006-2008. The short data time series did not allow applying a VPA. LCA was performed using VIT software on data of the years 2006, 2007 and 2008.

5.43.4.1.2. Input parameters

Tab. 5.43.4.1.2.1. Input demographic data for LCA of anchovy in GSA 09.

TL (cm)	2006	2007	2008
8.5	46288	44610	0
9.0	1144862	80000	0
9.5	6100858	115163	0
10.0	7534609	877083	0
10.5	6825240	6220585	87699
11.0	9425674	30112305	492554
11.5	17518291	37120653	2245792
12.0	29458585	26235110	5071005
12.5	40677382	15163731	5741202
13.0	40266366	8825793	6560542
13.5	31818496	7175348	7188870
14.0	20350313	6669320	8568716
14.5	15528384	4730219	7526367
15.0	9622502	3620976	5795897
15.5	4174503	2130108	4275409
16.0	1595153	665510	3023158
16.5	997262	251577	1120389
17.0	93415	68988	223311
17.5	46707	34494	82661

The following set of parameters was used:

Growth parameters (Von Bertalanffy)
$L\infty$ = 186 (mm, length)
K = 0.6
to = - 0.80
L*W
a = 0.006
b = 3.081
Natural mortality
M vector Age_1=1.32 , Age_2=0.52, Age_3=0.40, Age_4=0.35, Age_5=0.35
q(age 1+) = 1.0, q(age 2+) = 1.0, q(age 3+)= 1.0, q(age 4+)= 1.0, q(age 5+)= 1.0
Length at maturity (L_{50})
L_{50} = 11.6 cm

The vector of natural mortality M was estimated using the software Prodbiom.

5.43.4.1.3. Results

The general results of LCA highlight an exploitation focused on young age classes, mainly 0+ and 1+. Some differences were found comparing the results obtained for 2007 in respect to the other two years. In 2007 the exploitation was mainly directed on the first age class. This pattern is not the consequence of a change in the exploitation pattern by the fleet but probably is more related to the higher abundance of juvenile anchovy during that year. Anchovy is a typical small pelagic species with high recruitment fluctuation from one year to another.

For the mean value of F, a similar pattern has been observed for the three years, with higher values for the age classes 1+ and 2+.

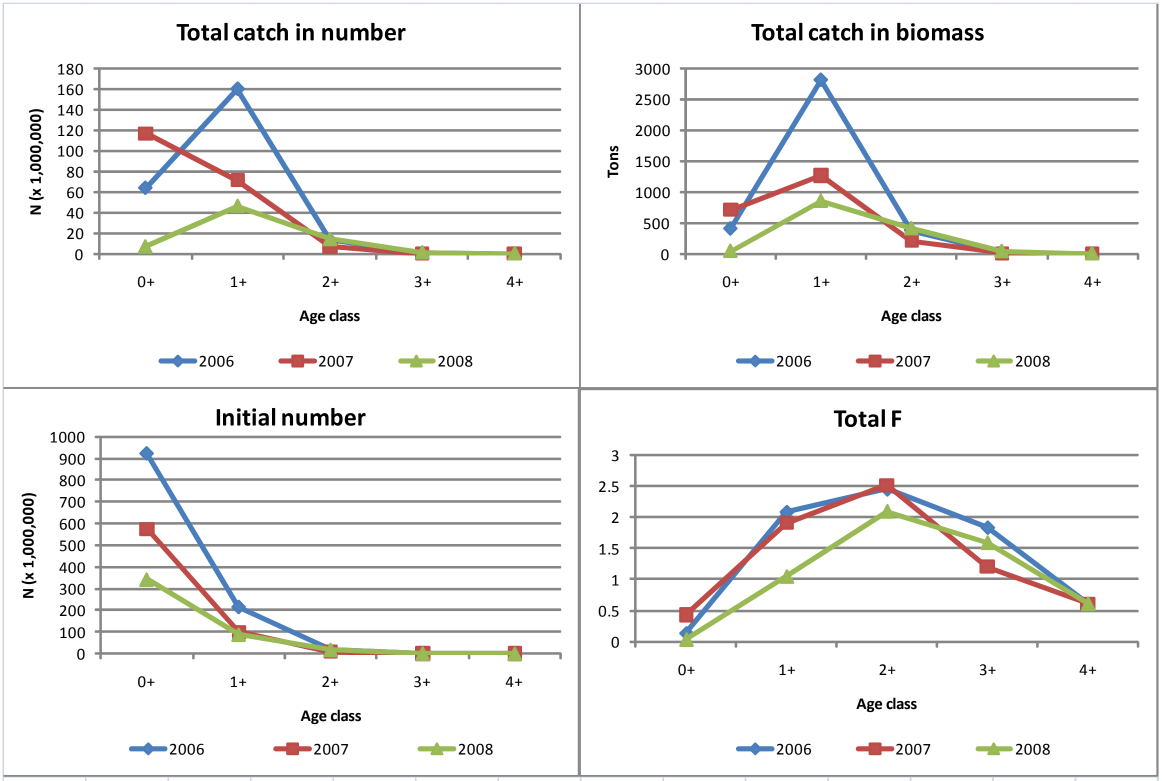


Fig. 5.43.4.1.3.1. LCA outputs: catch numbers, numbers-at-age, initial number and fishing mortality at age of anchovy in the GSA 09.

The mean fishing mortality, computed excluding the first age class, as it is not fully exploited by the fleet, shows high values with a tendency to the reduction over time. The correspondent exploitation rates resulted quite constant among the three years analyzed. The values are very high when compared with the reference value of 0.4 suggested by SGMED for small pelagic species.

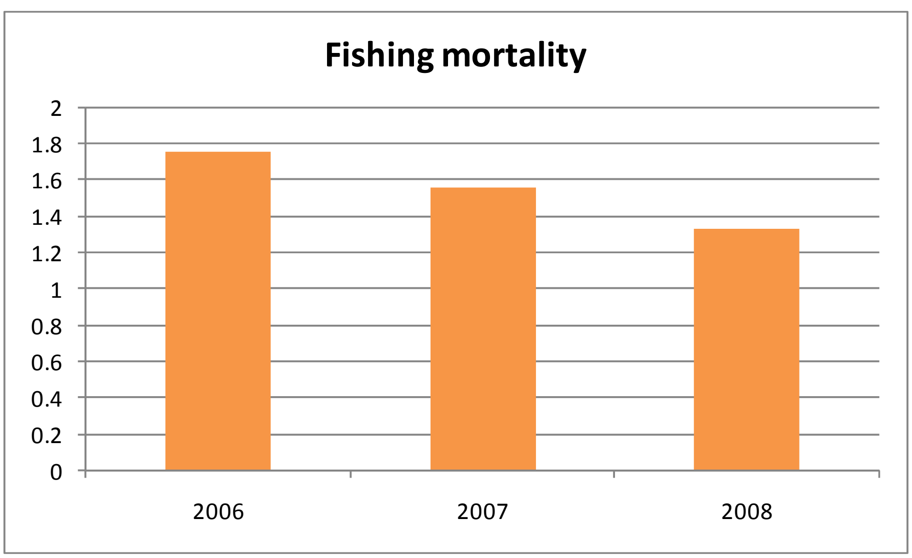


Fig. 5.43.4.1.3.2. LCA outputs: mean annual fishing mortality of anchovy in the GSA 09.

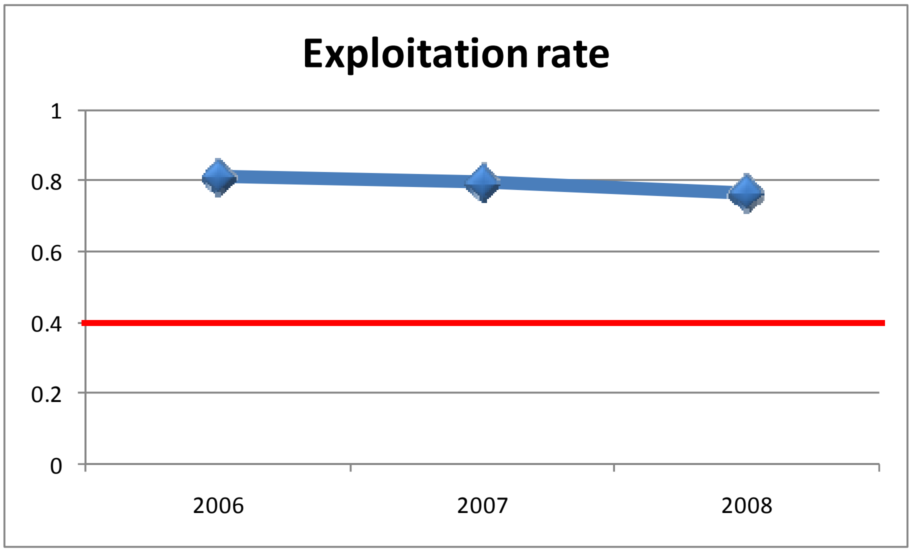


Fig. 5.43.4.1.3.3. LCA outputs: exploitation rate of anchovy in the GSA 09.

5.43.5. Long term prediction

5.43.5.1. Justification

No forecast analyses were conducted.

5.43.5.2. Input parameters

No forecast analyses were conducted.

5.43.5.3. Results

Given the preliminary state of the data and analyses, SGMED 10-02 is not in the position to provide a long term prediction of catch and stock biomass for anchovy in GSA 09.

5.43.6. Data quality

Biological data of the landing for 2009 were not available to SGMED 10-02 as the data were not submitted by the Italian authorities. Data concerning fishing activity and fishing effort of the purse seine fleet are referred only to 2004 and 2005. Moreover, the values reported to SGMED 10-02 seems to be incorrect. For the assessment, data coming from official data not reported through the Official Data call have been used.

5.43.7. Scientific advice

5.43.7.1. Short term considerations

5.43.7.1.1. State of the spawning stock size

In the absence of proposed or agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of biomass. The analyses carried out on the data referred to the period 2006-2008 do not allow to obtain information on the spawning stock biomass. However, both landings and survey indices indicate the stock being at a low level recently (2004-2008).

5.43.7.1.2. State of recruitment

The analyses carried out on the data referred to the period 2006-2008 do not allow to obtain information on the state of recruitment.

5.43.7.1.3. State of exploitation

SGMED-10-02 proposes E=0.4 as limit management reference point consistent with high long term yields. The current exploitation rate is higher than the reference point suggested by Patterson (0.4). Applying the exploitation rate as a reference point, this stock must be considered as overexploited and F needs a consistent reduction from the current value towards the candidate reference points to achieve long term sustainability.

The results obtained from the assessments performed for the period 2006-2008, associated to the heavy reduction of the landings observed in the last twenty years suggest the adoption of plan for the recovery of this important resource as a matter of urgency. All the management options need to taken into account the effect on sardine, the other important resource exploited by this fishery.However, this is the first attempt to assess anchovy in the GSA 09 and, taking into account the short data series available for the evaluation, further analyses should be carried out.

The purse seine fleet operating in the GSA 09 contemporary exploit anchovy and sardine. This aspect should be taken into account for the management options that will be implemented in the future.

5.44. Stock assessment of anchovy in GSA 16

Given that there were no data provided to update the stock assessment of anchovy in GSA 16, SGMED-10-02 presents the assessment as conducted in 2009 by SGMED-09-02.

5.44.1. Stock identification and biological features

5.44.1.1. Stock Identification

This assessment of the anchovy stock in GSA 16 is mainly based on information collected over the last decade relating fishery grounds off the southern Sicilian coast (GSA 16, South of Sicily), and specifically using biomass estimates obtained by hydro-acoustic surveys and catch/effort data from local small pelagic fisheries. The main distribution area of the anchovy stock in GSA 16 is the narrow continental shelf area between Mazara del Vallo and the southernmost tip of Sicily, Cape Passero (Patti *et al*., 2004). Daily Egg Production Method (DEPM) surveys were also carried out starting from 1998, giving also information on spawning areas distribution.

5.44.1.2. Growth

Growth parameters were not used for this assessment.

5.44.1.3. Maturity

Maturity data were not used for this assessment.

5.44.2. Fisheries

5.44.2.1. General description of fisheries

In Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16, two operational units (OU) are presently active, purse seiners and pelagic pair trawlers. The fleet in GSA 16 is composed by about 50 units (17 purse seiners and 30 pelagic pair trawlers were counted up in a census carried out in December 2006). In both OUs, anchovy represents the main target species due to the higher market price.

5.44.2.2. Management regulations applicable in 2009 and 2010

Fisheries policy is strongly conditioned by EU regulations through the Common Fisheries Policy (CFP), based on the following principles: protection of resources; adjustment of (structure) facilities to the available resources; market organization; and definition of relationships with other countries.

The main technical measures regulating fishing concern minimum landing size (9 cm for anchovy, 11 cm for sardine), mesh regulations (20 mm for pelagic pair trawlers, 14 mm for purse seiners) and restrictions on the use of fishing gear. Towed fishing gears are not allowed in the coastal area in less than 50 m depth, or within a distance of 3 nautical miles from the coastline. A seasonal closure for trawling, generally during summer-autumn, has been established since 1993. In GSA 16, two operational units fishing for small pelagic are based in Sciacca port: purse seiners (lampara vessels, locally known as “Ciancioli”) and midwaters pair trawlers (“Volanti a coppia”). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. Another fleet fishing on small pelagic fish species is based in some northern Sicilian ports and targets on juvenile stages (mainly sardines). Also this fishery is allowed for a limited period (usually one or two months during the winter season) by a special Regional law renewed year by year.

5.44.2.3. Catches

5.44.2.3.1. Landings

Landings were obtained within the framework of the census data collection carried out by IAMC-CNR (Mazara del Vallo) in Sciacca port since 1998. Information collected in the framework of CA.SFO. study project (Patti et al., 2007) showed that landings in Sciacca port account for about 2/3 of the total landings in GSA 16. Average anchovy landings in Sciacca port over the last decade (1997-2008) were about 1,600 metric tons, with large inter-annual fluctuations.

It is worth noting that, though trend in biomass is clearly decreasing over the last years (Fig. 5.44.2.3.1.1), landings levels over the same period were relatively high, indicating an increased vulnerability of the resource.

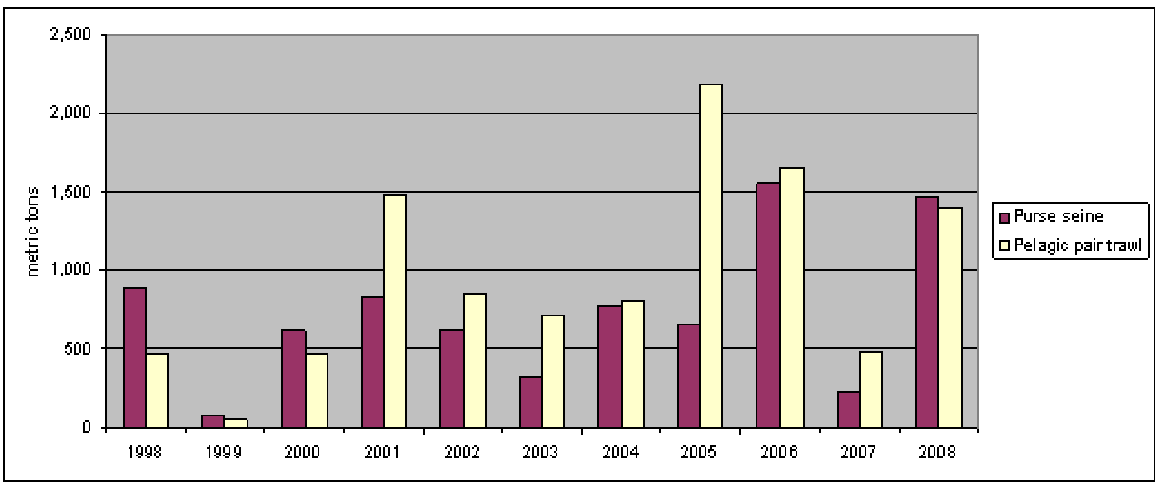


Fig. 5.44.2.3.1.1. Landings data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2008.

5.44.2.3.2. Discards

No discards data for anchovy were used for this assessment. However, discards are estimated to be less than 5% of total catch for both the pelagic pair trawl and the purse seine fisheries (Kallianiotis and Mazzola, 2002).

5.44.2.3.3. Fishing effort

Fishing effort data refer to census data collected in Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16.

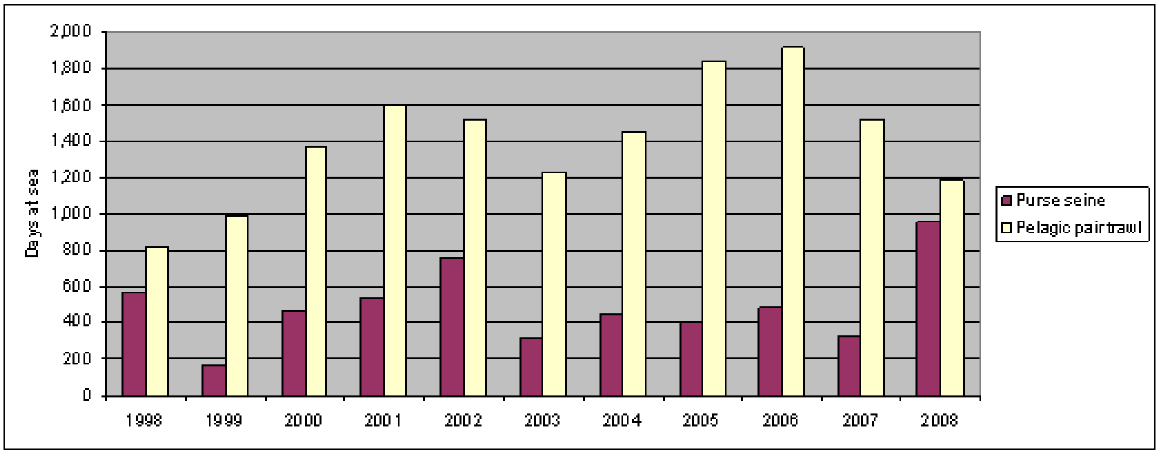


Fig. 5.44.2.3.3.1. Effort data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2008.

5.44.3. Scientific surveys

5.44.3.1. Acoustics

5.44.3.1.1. Methods

Acoustic surveys methodology

Steps for biomass estimation

- Collection of acoustic and biological data during surveys at sea;
- Extraction of $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) by means of Echoview (Sonar Data) post-processing software;
- Link of NASC values to control catches;
- Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data;
- Production of ρ distribution maps for different fish species and size classes;
- Integration of density areas for biomass estimation.

Collection of acoustic and biological data

Since 1998 the IAMC-CNR has been collecting acoustic data for evaluating abundance and distribution pattern of small pelagic fish species (mainly anchovy and sardine) in the Strait of Sicily (GSA 16). The scientific echosounder Kongsberg Simrad EK500 was used for acquiring acoustic data until summer 2005; for the echosurvey in the period 2006-2009 the EK60 echosounder was used. In both cases the echosounder was equipped with three split beam transducers pulsing at 38, 120 and 200 kHz. During the period 1998-2008 acoustic data were collected continuously during day and night time; since the 2009 echosurvey acoustic data are collected during day time, according to the MEDIAS protocol.

Before or after acoustic data collection a standard procedure for calibrating the three transducers was carried out by adopting the standard sphere method (Johannesson and Mitson, 1983).

Biological data were collected by a pelagic trawl net with the following characteristics: total length 78 m, horizontal mouth opening 13-15 m, vertical mouth opening 6-8 m, mesh size in the cod-end 10 mm. The net was equipped with two doors with weight 340 kg. During each trawl the monitoring system SIMRAD ITI equipped with trawl-eye and temp-depth sensors was adopted.

Extraction of $NASC_{Fish}$ by means of Echoview (Sonar Data) post-processing software

The evaluation of the $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) and the total NASC for each nautical mile of the survey track was performed by means of the SonarData Echoview software v3.50, taking into account the day and night collection periods.

Link of NASC values to control catches

For the echo trace classification the nearest haul method was applied, taking into account only representative fishing stations along transects.

Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data

For each trawl haul the frequency distribution of the j-th species (ν_j) and for the k-th lenght class (f_{jk}) are estimated as

$$\nu_j = \frac{n_j}{N} \qquad \text{and} \qquad f_{jk} = \frac{n_{jk}}{n_j}$$

where n_j is the total number of specimens of the j-th species, n_{jk} is the total number of specimens of the k-th lenght class in the j-th species, and N is the total number of specimens in the sample.

For each nautical mile the densities for each size class and for each fish species are estimated as

$$\rho_{jk} = \frac{NASC_{FISH} * n_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(number of fishes / n.mi}^2\text{)}$$

$$\rho_{jk} = \frac{NASC_{FISH} * W_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(t / n.mi}^2\text{)}$$

where W_{jk} is the total weight of the k-th lenght class in the j-th species, and σ_{jk} is the scattering cross section of the k-th lenght class in the j-th species. σ_{jk} is given by

$$\sigma_{spjk} = 4\pi * 10^{\frac{TS_{jk}}{10}}$$

where the target strenght (TS) is

$$TS_{jk} = a_j Log_{10}(L_k) + b_j$$

L_k is the length of the k-th lenght class while the a_j and b_j coefficient are linked to the fish species.

For anchovy, sardine and trachurus we adopted respectively the following relationships:

$TS = 20 \log L_k\ 76.1$ [dB]

$TS = 20 \log L_k\ 70.51$ [dB]

$TS = 20 \log L_k\ 72$ [dB]

Integration of density areas for biomass estimation

The abundance of each species was estimated by integrating the density surfaces for each species.

5.44.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.44.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the anchovy stock in GSA 16 was derived from the acoustics. Figure 5.44.3.1.3.1 displays the estimated trend in anchovy Total Biomass (estimated by acoustics) for GSA 16.

A decreasing trend was observed in biomass during the last years (Fig. 5.44.3.1.3.1).

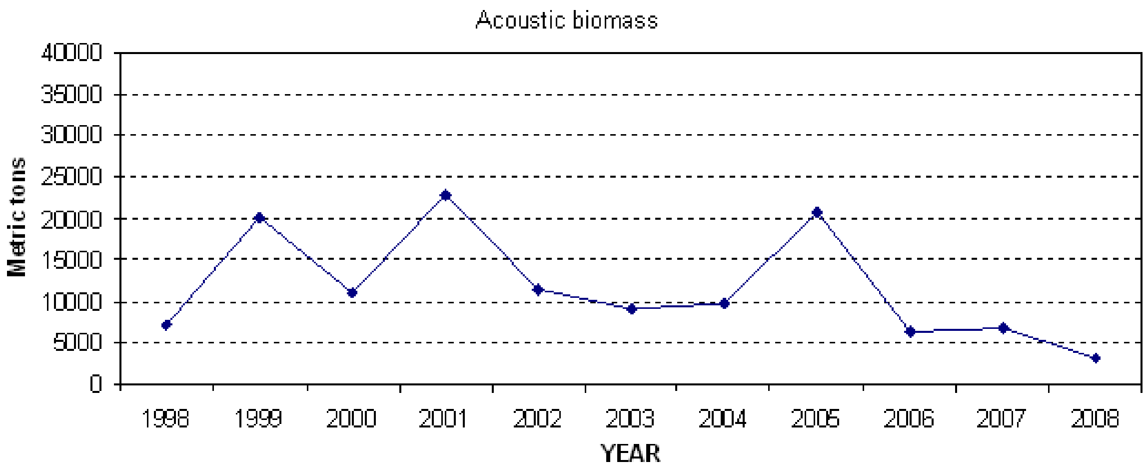


Fig. 5.44.3.1.3.1. Estimated anchovy biomass indices for GSA 16, years 1998-2008.

5.44.3.1.4. Trends in abundance by length or age

Length or age class data were not used for this assessment.

5.44.3.1.5. Trends in growth

Growth data were not used for this assessment.

5.44.3.1.6. Trends in maturity

Maturity data were not used for this assessment.

5.44.4. Assessment of historic stock parameters

Not applicable. No stock assessment model was run for this assessment.

5.44.5. Long term prediction

Not applicable. No forecast analyses were conducted.

5.44.6. Scientific advice

5.44.6.1. Short term considerations

5.44.6.1.1. State of the spawning stock size

Biomass estimates of total population obtained by hydro-acoustic surveys for anchovy in GSA 16 show a decreasing trend over the last years. The 2008 estimate is the lowest value of the series and represents approximately just one-tenth of the maximum recorded value. However, in the absence of proposed or agreed references, SGMED-10-02 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them.

5.44.6.1.2. State of recruitment

No recruitment data were provided by this assessment.

5.44.6.1.3. State of exploitation

SGMED-10-02 proposes E=0.4 as limit management reference point consistent with high long term yields.

The high and increasing yearly exploitation rates, as estimated by the ratio between total landings and biomass, indicates high fishing mortality levels. If this estimate of exploitation rate can be considered as equivalent to F/Z estimate obtained from the fitting of standard stock assessment models, the current exploitation (0.64) is higher than the reference point suggested by Patterson (1992). The fishing mortality level corresponding to F/Z=0.64 is F=1.17, if M=0.66, estimated with Pauly's (1980) empirical equation, is assumed.

Using the exploitation rate as a reference point, this stock should be considered as being overexploited.

Given that biomass was very low for three consecutive years (2006, 2007 and 2008), fishing effort should be reduced by means of a multi-annual management plan until there is evidence for stock recovery. Consistent catch reductions along with effort reductions should be determined. The mixed fisheries effects, mainly the interaction with sardine, need to be taken into account when managing the Anchovy fishery.

General considerations for the management of the Anchovy fishery:

Taking into account that fishing effort was relatively stable in last decade, whereas CPUE trend was even increasing, results would suggest the importance of environmental factors variability on yearly recruitment success and/or a possible increase in the vulnerability of the resource.

However, the stock biomass did not recover from the 2006 "collapse" in biomass (-69% from July 2005 to June 2006), and also further decreased (-53%) in 2008. This fact, along with the quite high and increasing level of exploitation rates experienced over the last years, also suggests questioning about the sustainability of current levels of fishing effort.

A warning on the fishing of larval stages (locally named *bianchetto*) is also relevant for anchovy population if derogation of the fishing ban, normally operated for GSA 16 in wintertime, is postponed after the start of the anchovy spawning season, even though more data and investigation are needed in order to estimate the possible impact of this fishing activity on the exploited populations.

5.45. Stock assessment of anchovy in GSA 20

5.45.1. Stock identification and biological features

5.45.1.1. Stock Identification

This assessment of the sardine stock in GSA 20 has been based on information derived from the Greek part of the Ionian Sea (GSA 20). In Ionian Sea the main distribution area of the anchovy stock includes coastal waters mainly located in Patraikos Gulf and in the area between the mainland and the islands of Leukas, Cephalonia and Corfu.

5.45.1.2. Growth

Fast growth parameter was considered and parameters are shown in Table 5.45.1.2.1. No sex discrimination was applied. Natural mortality M was estimated based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. As no growth parameters for anchovy stock in GSA 20 were available, the growth parameters used for GSA 22 were applied.

Tab. 5.45.1.2.1. Growth parameters (v. Bertalanffy) for anchovy in GSA 20.

	Fast growth Unsexed	Units
Linf	191	cm
K	0.385	year^{-1}
t0	-1.559	year
a	0.00004	gr
b	3.1157	
M age 0	1.5	year^{-}
M age 1	1	year^{-}
M age 2	0.72	year^{-}
M age 3	0.66	year^{-}
M age 4	0.62	year^{-}

5.45.1.3. Maturity

The following proportions of maturity at age were used for assessments in GSA 20 as estimated from biological sampling and the DEPM surveys held in GSA 22 (Somarakis *et al.*, 2004; 2007). The anchovy spawning period in GSA 22 extends from May to August with a peak in June-July. The major spawning grounds of anchovy in the Ionian Sea are located within gulfs, like Patraikos gulf or in the area between the islands and the mainland, mainly associated with rivers outflow.

5.45.2. Fisheries

5.45.2.1. General description of fisheries

Anchovy (*Engraulis encrasicolus*) is one of the most important target species for the purse seine fishery in GSA 20. Anchovy is being exploited only by the purse seine fishery. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Commonly anchovy is caught from shallow waters about 30 m to 100 m depth.

5.45.2.2. Management regulations applicable in 2009 and 2010

Regarding the management regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore (300 m), minimum bottom depth (30 m), gear and mesh size, engine, GRT restrictions etc. There is also a minimum landing size at 9 cm.

5.45.2.3. Catches

5.45.2.3.1. Landings

The trend in reported landings (from Greek purse seiners fleet) is shown in Figs. 5.45.2.3.1.1 and 5.45.2.3.1.2. Landings were obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers GSA 20. An increasing trend in anchovy landings has been observed (Fig. 5.45.2.3.1.1). Data of the landings indicate that small vessels (12-24 m) are entirely responsible for anchovy catches (Fig. 5.45.2.3.1.2).

Annual length distribution of landings was reported to SGMED-10-02 for 2003-2006 and 2008. Annual length distribution of landingsfor the period 2000-2008 is shown in Fig. 5.45.2.3.1.3. No data on the age distribution of landings was reported to the SGMED-10-02, through the DCR. Fig. 5.45.2.3.1.4 shows the landings at age in GSA 20 for 2000-2008. Data for 2007 and 2008 are based on data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers GSA 20.

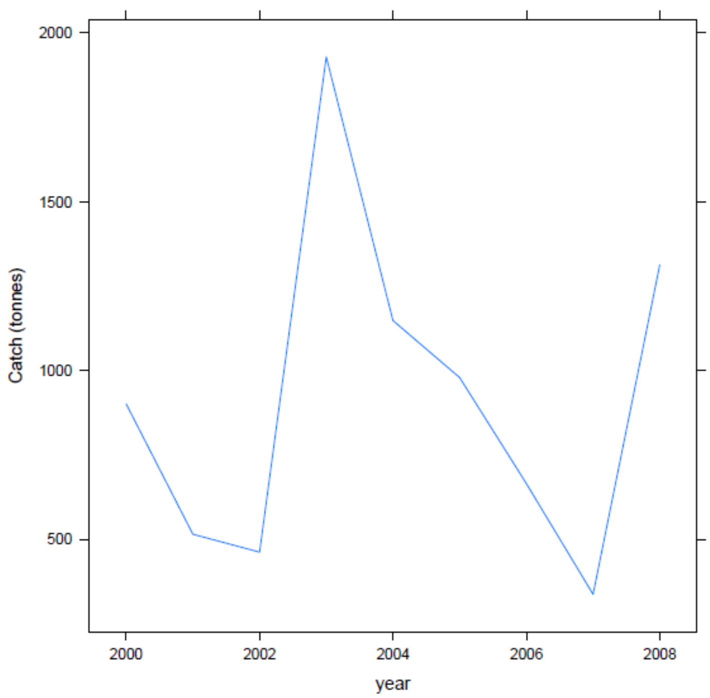


Fig. 5.45.2.3.1.1 Anchovy landings (t) in GSA 20 for 2000-2008.

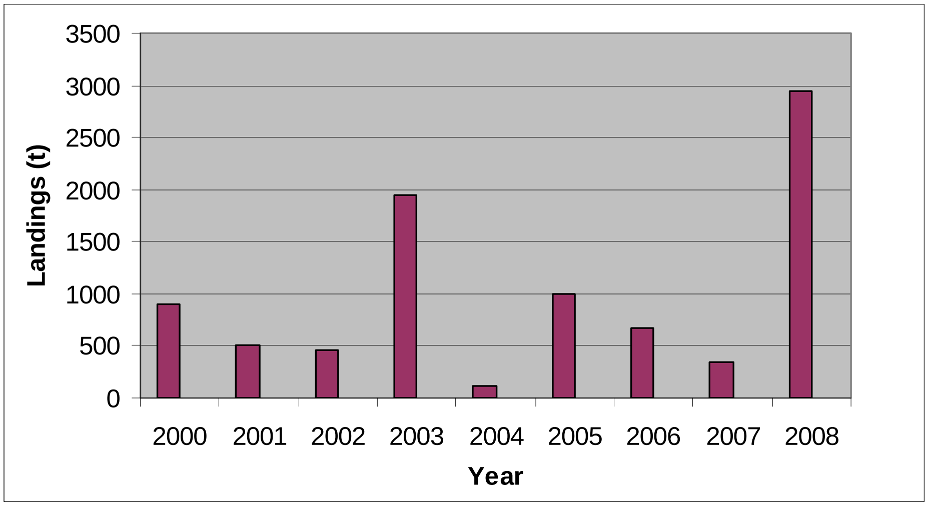


Fig. 5.45.2.3.1.2 Anchovy landings (t) in GSA 20 for Purse Seine: 12-24 m.

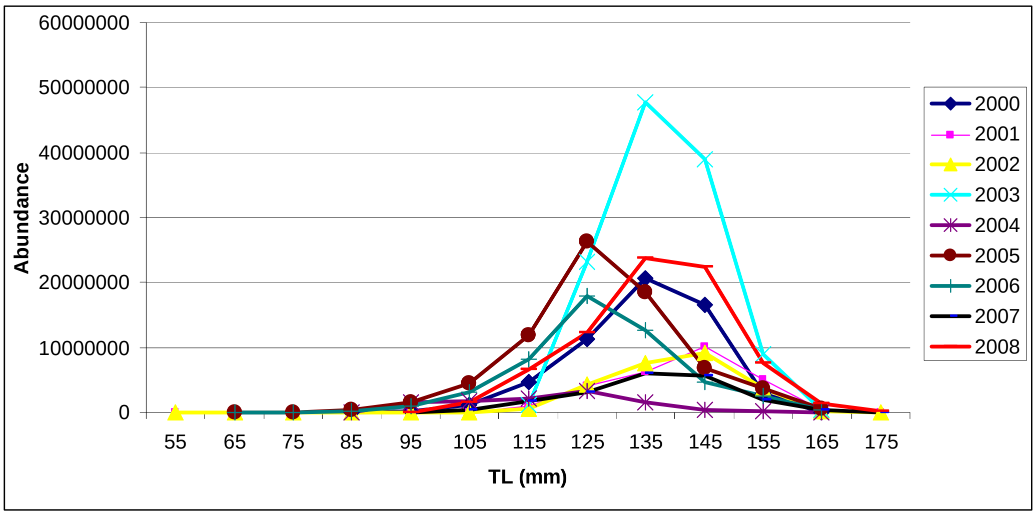


Fig. 5.45.2.3.1.3 Length frequency distribution of anchovy landings (t) in GSA 20 for 2000-2008.

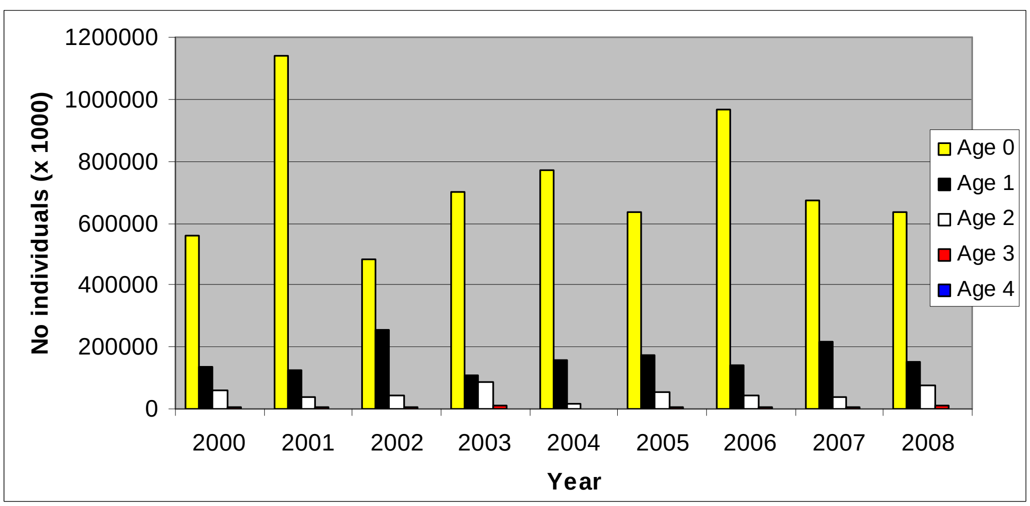


Fig. 5.45.2.3.1.4 Anchovy landings per age group (number of individuals in thousands) in GSA 20 for 2000-2008.

5.45.2.3.2. Discards

No discards data for anchovy were reported to the SGMED-10-02 and no data were reported through the Data collection regulation for 2003-2008. According to data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 20, discards are estimated to less than 1%, consisting 0.06% of the purse seine fishery total catch. Although considered negligible they were taken into account for the assessment as a percentage to reported landings. The fishery is multispecies and fishermen tend to avoid schools of undersized anchovies due to sorting difficulties (blocking of the mesh) and low price, practically by using nets of bigger mesh size, targeting mostly mackerels or horse mackerels.

5.45.2.3.3. Fishing effort

Based on the fishing effort data reported through the Data collection regulation and data obtained within the framework of the Hellenic Centre for Marine Research data collection system covering the entire GSA 20, the following table was made:

Tab. 5.45.2.3.3.1 Effort data for the purse seine fleet in GSA 20 (GT=Gross tonnage, KW=engine power).

Year			PS 12-24 m	
	Active Fleet	Total Days at Sea	Days at Sea x GRT	Days at sea x KW
2003	281	3377	66113	454877
2004	215	2604	54104	355157
2005	294	4342	163038	529175
2006	268	3782	128970	426087
2008	283	3982	111059	487907

5.45.3. Scientific surveys

No acoustic or DEPM scientific surveys were held in GSA 20 concerning the monitoring of anchovy stock.

5.45.3.1.1. Methods

No acoustic or DEPM scientific surveys were held in GSA 20.

5.45.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.45.3.1.3. Trends in abundance and biomass

No analyses were conducted during SGMED-10-02.

5.45.3.1.4. Trends in abundance by length or age

No analyses were conducted during SGMED-10-02.

5.45.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.45.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.45.4. Assessment of historic stock parameters

5.45.4.1. Method: XSA

5.45.4.1.1. Justification

Extended Survivors Analysis (XSA) for stock assessment (Shepherd, 1999) was applied. XSA uses virtual population analysis (VPA) (Pope & Shepherd, 1985) with weighted tuning indices. XSA focuses on the relationship between catch per unit effort and population abundance, allowing the use of a more complicated model for the relationship between CPUE and year class strength at the youngest ages. It was applied to the anchovy stock in GSA 20 due to the lack of survey indices in the area. In addition Y/R analysis was applied during the SGMED-10-02.

5.45.4.1.2. Input parameters

XSA was based on commercial catch data (2000-2008) and as tuning index the Catch per Unit Effort of the purse seine fleet per age group (kg/days at sea) was used, over the period 2003-2008.

Anchovy data concerned annual anchovy landings, annual anchovy catch at age data (2000-2008), mean weights at age, maturity at age and CPUE (2003-2008) are presented in Tables 5.45.4.1.2.1 to 5.45.4.1.2.5. Settings for the XSA model are summarized in Tab. 5.45.4.1.2.1. Different natural mortality values were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01 (Tab. 5.45.1.2.1). This method of the estimation of the natural mortality is consistent with the methodology used in GSAs 01, 06, 17 and 22 for small pelagics. Concerning the lack of acoustic information for 2007, average values were used concerning the maturity ogive and the weight at age in the stock.

Tab. 5.45.4.1.2.1. XSA model settings.

Time series weights :	Tapered time weighting applied
Power =	3 over 6 years
Catchability analysis	
Catchability independent of size for ages	> 2
Catchability independent of age for ages	> 3
Terminal population estimation :	
Survivor estimates shrunk towards the mean F	of the final 6 years or the 2 oldest ages
S.E. of the mean to which the estimates are shrunk =	0.5
Minimum standard error for population estimates derived from each fleet =	0.3
prior weighting	not applied

Tab. 5.45.4.1.2.2. Catch at age (numbers in thousands) of anchovy stock in GSA 20 for 2000-2008.

Year	0	1	2	3	4
2000	606	22401	31507	2789	308
2001	103	8425	15844	2210	420
2002	68	8310	15117	1862	319
2003	93	41266	71228	6856	864
2004	1196	6264	3271	222	12
2005	2061	35349	33465	2893	368
2006	1400	24016	22737	1966	250
2007	185	7185	10603	1234	238
2008	720	27946	41237	4801	924

Tab. 5.45.4.1.2.3. Catch estimates (in t) of anchovy stock in GSA 20 for 2000-2008.

Year	Anchovy
2000	901
2001	515
2002	462
2003	1949
2004	116
2005	990
2006	672
2007	341
2008	2943

Tab. 5.45.4.1.2.4. Weight at age in the catch of anchovy stock (in kg) in GSA 20 for 2000-2008.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2000	0.0082	0.0141	0.0162	0.0179	0.0208
2001	0.0078	0.0168	0.0193	0.0228	0.0260
2002	0.0080	0.0161	0.0182	0.0215	0.0251
2003	0.0099	0.0151	0.0163	0.0184	0.0218
2004	0.0087	0.0092	0.0132	0.0152	0.0213
2005	0.0072	0.0116	0.0146	0.0189	0.0283
2006	0.0072	0.0116	0.0146	0.0189	0.0283
2007	0.0092	0.0153	0.0182	0.0216	0.0263
2008	0.0092	0.0153	0.0182	0.0216	0.0263

Tab. 5.45.4.1.2.5. Maturity ogive of anchovy stock in GSA 20 for 2003-2008.

Year	**0**	**1**	**2**	**3**	**4**
2003	0	.62	.99	1	1
2004	0	.67	.99	1	1
2005	0	.46	.98	1	1
2006	0	.40	.98	1	1
2007	0	.40	.98	1	1
2008	0	.40	.98	1	1

Tab. 5.45.4.1.2.6. CPUE for age group of anchovy (kg/days at sea) stock in GSA 20 for 2003-2008. Age 3 was considered a plus age group.

	2003	2004	2005	2006	2007	2008
Age 1	185	22	94	74	28	102
Age 2	344	17	113	88	48	179
Age 3+	43	1	15	12	8	31

5.45.4.1.3. Results including sensitivity analyses

The residual plot of the catchability per age and year of the model shown in Fig. 5.45.4.1.3.1 generally showed good model fit besides the CPUE index at age 3 in 2003. This could be attributed either to the low representation of ages 3 and 4 in the catch and the population or due to misinterpretation of the age readings estimations.

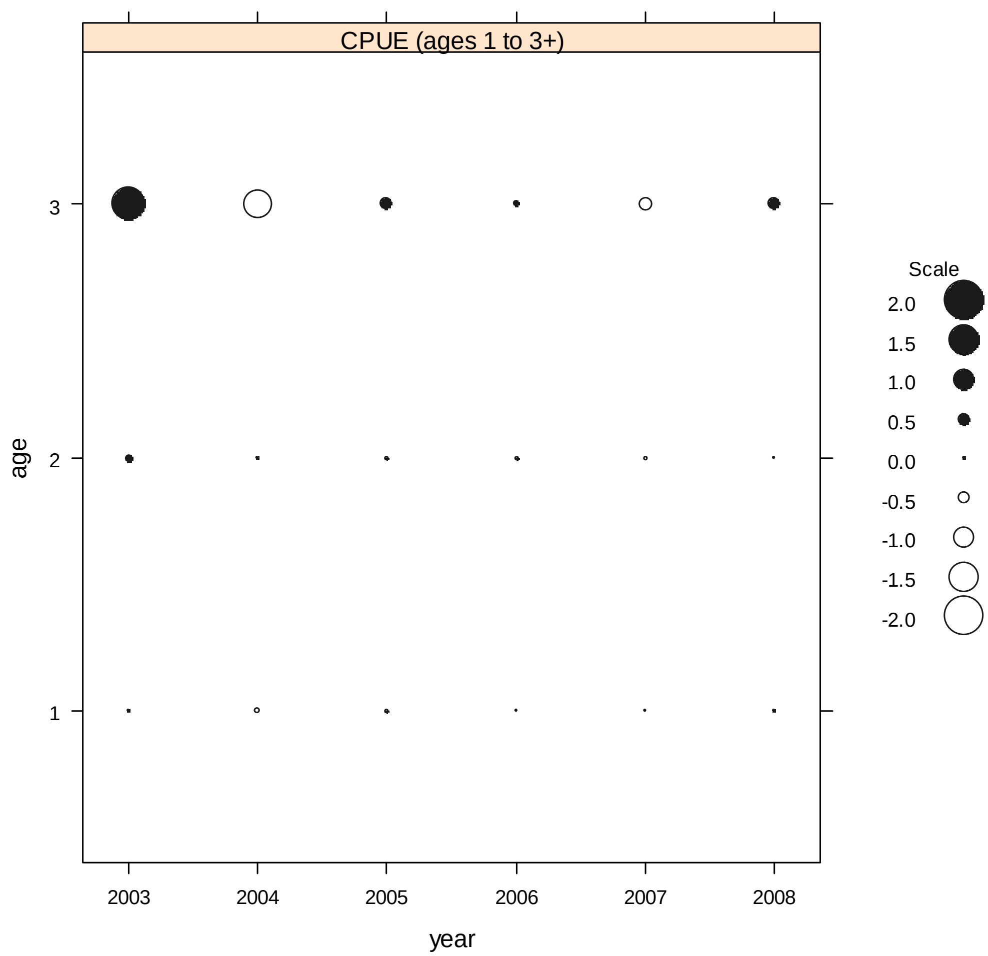


Fig. 5.45.4.1.3.1 Residual plot of index catchabilities per age and year of anchovy XSA model for GSA 20 (2003-2008)

The model diagnostics are also shown in Table 5.45.4.1.3.1.

Tab. 5.45.4.1.3.1. Anchovy XSA model diagnostics.
Regression weights

2000	2001	2002	2003	2004	2005	2006	2007	2008
-2.573	-0.203	0	0.075	0.348	0.67	0.893	0.986	1

Fleet: CPUE (ages 1 to 3+)

Log catchability residuals.

	2003	2004	2005	2006	2007	2008
1	0.024	-0.152	0.077	-0.026	-0.016	0.038
2	0.224	0.032	0.051	0.059	-0.081	-0.035
3	1.533	-1.283	0.423	0.168	-0.544	0.436

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Mean_Logq S.E_Logq
-5.6595 0.9591

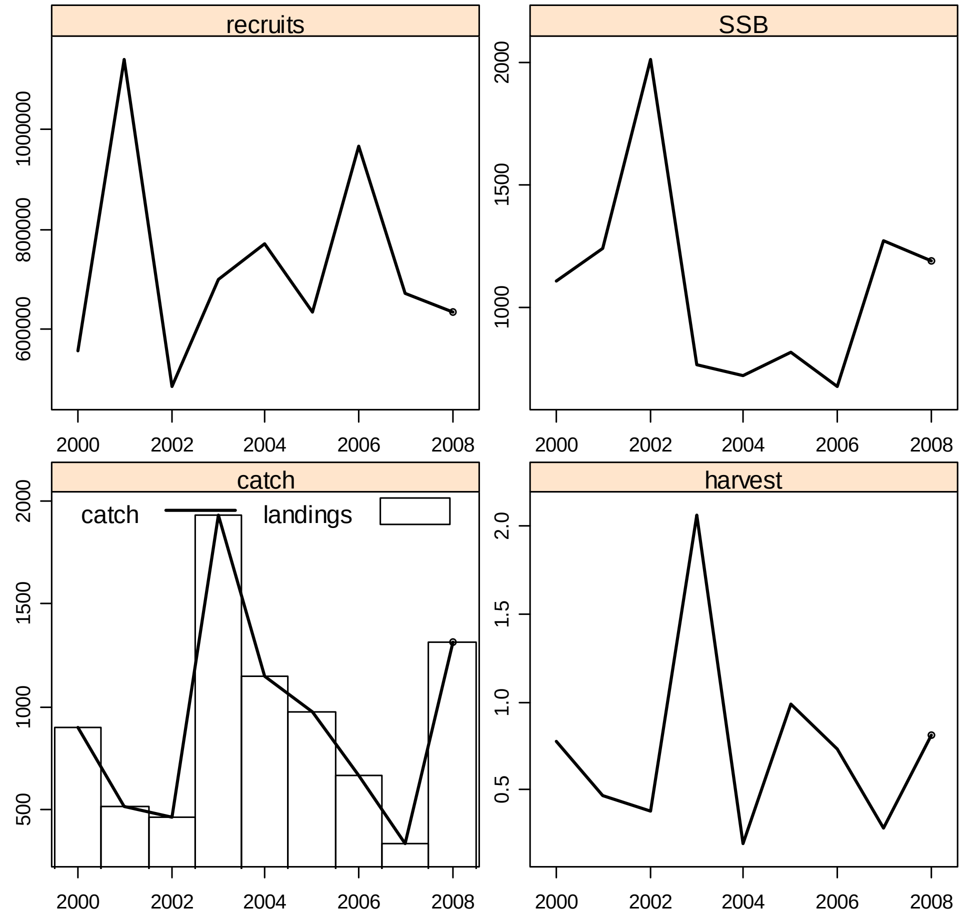
Regression statistics

	Ages with q dependent on year class strength	slope intercept
Age 1	-0.3503608	13.65323
Age 2	0.4576544	8.33364

Terminal year survivor and F summaries:

	scaledWts	survivors	yrcls
Age 0 Year class =2008			
fshk	1	141416	2008
Age 1 Year class =2007			
CPUE (ages 1 to 3+)	0.665	35331	2007
fshk	0.335	48845	2007
Age 2 Year class =2006			
CPUE (ages 1 to 3+)	0.435	9164	2006
fshk	0.565	10176	2006
Age 3 Year class =2005			
CPUE (ages 1 to 3+)	0.16	3961	2005
fshk	0.84	2596	2005

XSA model results for anchovy stock in GSA 20 are shown in Fig. 5.45.4.1.3.2 and 5.45.4.1.3.3, indicating the highest values of recruitment in 2001 and 2006 with a decrease since 2006 towards 2008. A decrease in SSB was observed since 2002 but with a slight increase since 2006 to 2008. Average fishing mortality for ages 1 to 3 (which are target ages for the fishery) shows a decrease since 2003. The estimated exploitation ratio seems to fluctuate around the 0.4 value.



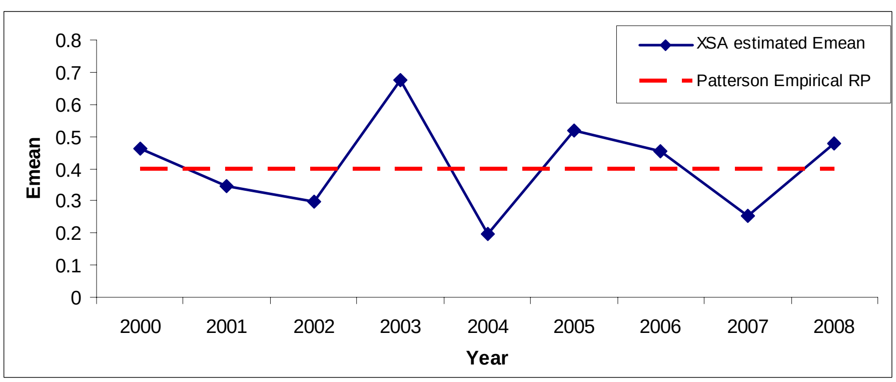


Fig. 5.45.4.1.3.2 Anchovy XSA Model (M variable per age group based on ProBiom estimations, CPUE index) results: Recruitment, SSB, Total biomass, Fmean for ages 1-3 and exploitation rate (F/Z).

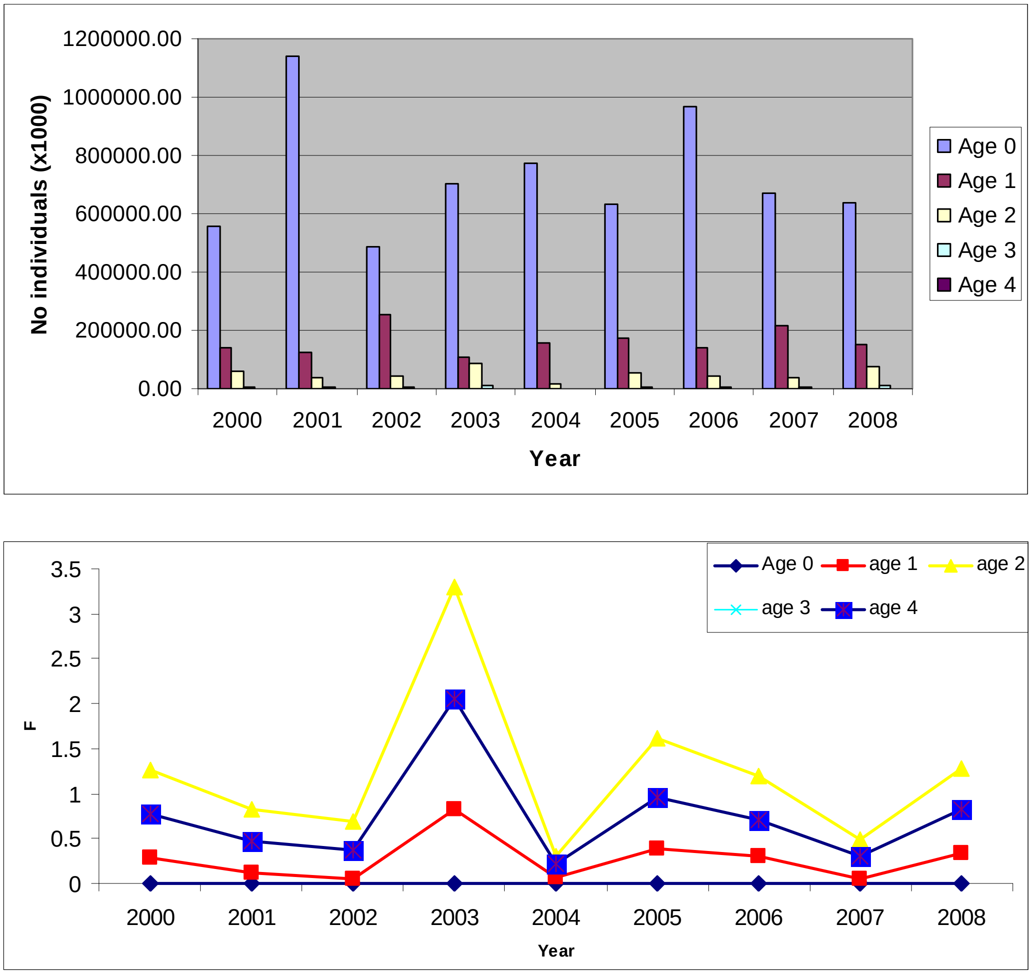


Fig. 5.45.4.1.3.3 Anchovy XSA Model (M variable per age group based on ProBiom estimations, CPUE index) results: Population at age and fishing mortality at age.

Table 5.45.4.1.3.2 Estimated fishing mortality at age, 2000-2008.

	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0	0	0	0	0	0.01	0	0	0
1	0.29	0.11	0.05	0.83	0.07	0.38	0.31	0.05	0.34
2	1.26	0.82	0.7	3.3	0.3	1.62	1.19	0.48	1.28
3	0.77	0.47	0.38	2.06	0.21	0.96	0.71	0.31	0.82
4	0.77	0.47	0.38	2.06	0.21	0.96	0.71	0.31	0.82

Table 5.45.4.1.3.3 Estimated stock numbers at age (thousands), 2000-2008.

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Age 0	557790	1140500	484750	700840	770850	634510	965640	672950	635180
Age 1	138010	124200	254430	108130	156340	171480	140690	214860	150080
Age 2	57945	38036	40832	88783	17302	53887	43138	38124	74880
Age 3	6794	7874	7961	9692	1567	6086	5105	6262	11236
Age 4	750	1496	1364	1221	77.66	774	649	1202	2162

Table 5.45.4.1.3.4 XSA stock summary table without SOP.

Year	Recruits	Total Biomass (tonnes)	Spawning Biomass (tonnes)	Landings (tonnes)	Yield/SSB ratio	F1-3	E
2000	557790	7540	1113	901	0.81	0.772	0.464
2001	1140500	11933.9	1241	515	0.41	0.468	0.347
2002	484750	8917.9	2017	462	0.23	0.375	0.299
2003	700840	10222.3	769	1929	2.51	2.063	0.676
2004	770850	8398.6	724	1148	1.58	0.194	0.198
2005	634510	7481.4	823	979	1.19	0.986	0.518
2006	965640	9329.3	678	665	0.98	0.734	0.456
2007	672950	10335.3	1272	337	0.26	0.281	0.254
2008	635180	9794.4	1191	1313	1.10	0.814	0.480

Bootstrapping of the XSA model was also applied with 100 iterations in order to have an estimation of the uncertainty in the SSB, recruitment and Fbar estimates. Results are presented in Fig. 5.45.4.1.3.4.

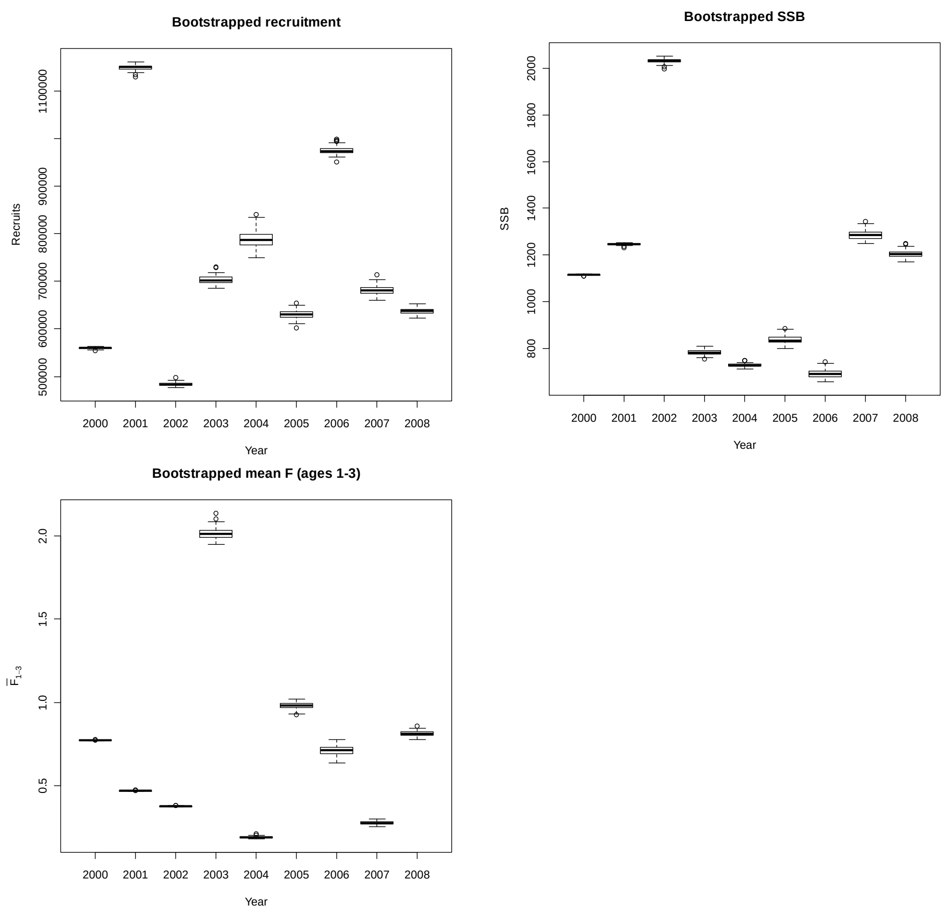


Fig. 5.45.4.1.3.4 Anchovy XSA Model (M variable per age group based on ProBiom estimations, CPUE index) results: Bootstrapped Recruitment, Bootstrapped SSB and bootstrapped Fmean for ages 1-3.

Retrospective analysis was applied in the XSA model for the Ionian Sea anchovy 2000-2008 with up to 5 years backward analysis. Results are presented in Fig. 5.45.4.1.3.5, showing large retrospective bias in the beginning of the time series and improvement in the latest years.

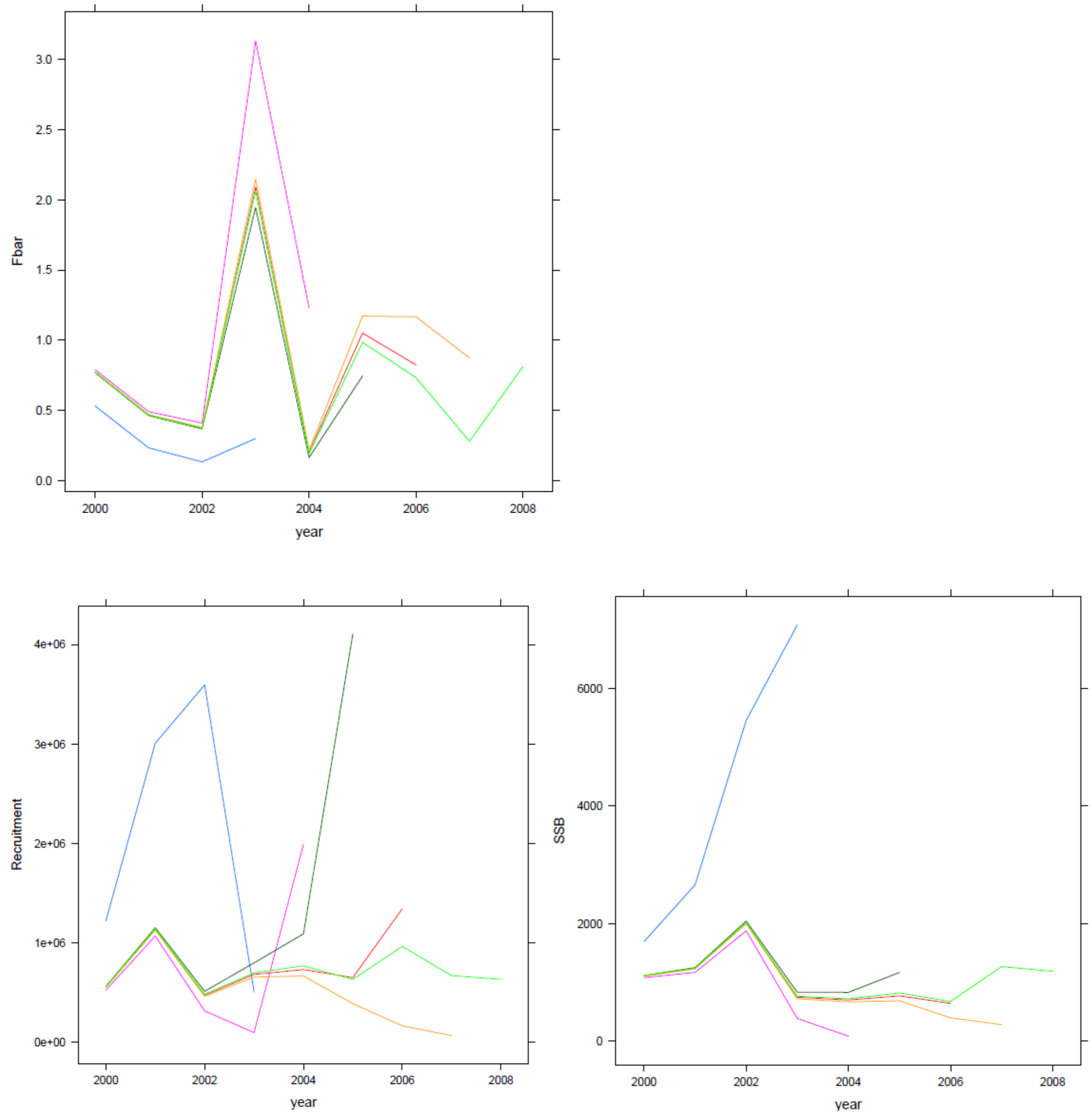


Fig. 5.45.4.1.3.5 The results of retrospective analysis in the Ionian Sea anchovy XSA model 2000-2008, concerning F mean 1-3, SSB and recruitment.

5.45.5. Long term prediction

5.45.5.1. Justification

Yield per recruit analysis was conducted in the SGMED-10-02 assuming equilibrium conditions.

5.45.5.2. Input parameters

Based on the exploitation pattern resulting from the XSA model and its population parameters, yield per recruit analyses were formulated. Minimum and maximum age for the analysis was considered to be age group 0 and 4, respectively. Stock weight at age, catch weight at age and maturity at age was estimated as mean values in a long term basis (2000-2008). Natural mortality was considered different per age group based on ProBiom estimations. Fishing mortalities were estimated in a short term basis (2004-2008). Reference F was considered to be mean F for ages 1 to 3. Input parameters are shown in Table 5.45.5.2.1.

Tab. 5.45.5.2.1. Input parameters for Y/R analysis.

age group	stock weight	catch weight	maturity	F	M
0	0.008	0.008	0	0.002	1.50
1	0.014	0.014	0.53	0.269	1.00
2	0.017	0.017	0.98	1.217	0.74
3	0.020	0.020	1	0.742	0.66
4	0.025	0.025	1	0.742	0.62

5.45.5.3. Results

Y/R analyses were performed (Fig. 5.45.5.3.1) but were not considered reliable due to its flat-topped shape. Therefore, $F_{0.1}$ (1.48) cannot be used as a reference point for this stock.

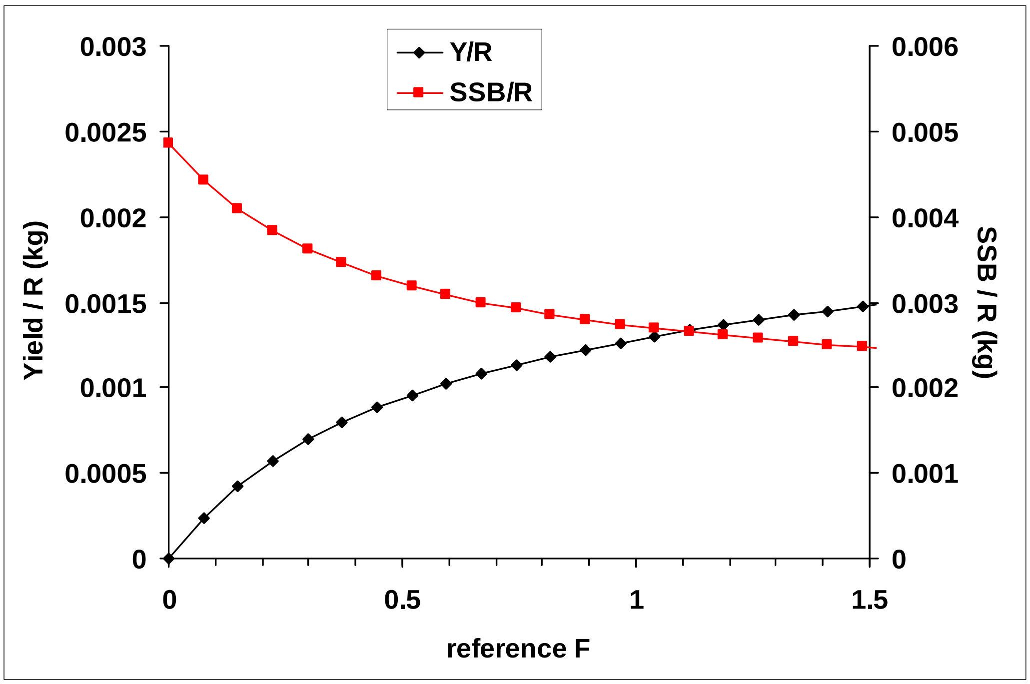


Fig. 5.45.5.3.1. Yield per recruit for the anchovy stock in GSA 20.

5.45.6. Data quality and availability

The data collected in 2003 to 2006 and 2008 although reported to SGMED-10-02 through the Data Collection Framework (DCF) did not include discards estimations. Data from 2007 were missing (DCF was not carried out) so input data were based on unreported data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers GSA 20. Data for 2009 were not available as DCF was not carried out in Greece last year.

Due to the lack of fishery independent information to be used as tuning fleet in the assessment, the unstandardised CPUE of the purse seine fleet was used to tune the XSA. However, since the purse seine fleet showed a sharp increase in capacity since 2005, SGMED consider that this could result into an underestimation of the exploitation rate. SGMED also underline the need of conducting data collection and surveys on an annual basis to allow for the assessment of the stock in the future.

5.45.7. Scientific advice

5.45.7.1. Short term considerations

5.45.7.1.1. State of the spawning stock size

Estimates of XSA stock assessment model for anchovy in GSA 20 indicated a decrease in SSB since 2002 but with a slight increase since 2006 to 2008 reaching 1200 t in 2008. In the absence of proposed or agreed precautionary reference points, SGMED-10-02 is unable to fully evaluate the state of the stock in respect to biomass reference points.

It should be considered that this assessment is based on a short time series of data and not suitable to suggest reference points of B_{lim}. Moreover, anchovy is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends on environmental conditions.

5.45.7.1.2. State of recruitment

XSA model results for anchovy stock in GSA 20 indicated the highest values of recruitment in 2001 and 2006, decreasing however towards 2008.

5.45.7.1.3. State of exploitation

SGMED-10-02 proposes E=0.4 as limit management reference point consistent with high long term yield.

Based on XSA results, the mean fishing mortality (averaged over ages 1 to 3) is highly variable fluctuating around 0.4. However, since XSA was tuned with unstandardised CPUE of the purse seine fleet, exploitation rates might be underestimated. The purse seine fleet showed a sharp increase concerning its capacity since 2005 that might bias the model estimates, resulting into underestimation of the exploitation rate.

The mean F/Z concerning the anchovy stock in GSA 20 was on average above (mean value of the entire time series equals 0.41) the empirical level of sustainability (E<0.4, Patterson 1992) for small pelagics. Taking into account that this value could be an underestimation of the actual situation, the SGMED recommends a reduction in fishing mortality in order to reach the F/Z= 0.4, promote stock recovery and avoid future loss in stock productivity and landings.

Fishing mortality should be reduced in order to allow future recruitment contributing to stock productivity. This requires also consideration of the mixed fisheries nature of the fleets.

5.46. Stock assessment of anchovy in GSA 22

Given that there were no data provided to update the stock assessment of anchovy in GSA 22, SGMED-10-02 presents the assessment as conducted in 2009 by SGMED-09-02.

5.46.1. Stock identification and biological features

5.46.1.1. Stock Identification

This assessment of the anchovy stock in GSA 22 has been based on information derived from the Greek part of the Aegean Sea (GSA 22). The main distribution area of the anchovy stock in Aegean Sea is located in the continental shelf of the northern Aegean Sea (Giannoulaki *et al*., 2004; 2008; Somarakis *et al*., 2007). Anchovy juveniles spatial distribution is strongly related to semi closed gulfs, shallow waters (less than 50 m depth) with high productivity, often related to areas of rivers outflows (Tsagarakis *et al*., 2007; 2008; SARDONE project interim report).

5.46.1.2. Growth

Fast growth parameter was considered and parameters are shown in Table 5.46.1.2.1. No sex discrimination was applied. Natural mortality M was estimated based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01.

Tab. 5.46.1.2.1. Growth parameters (v. Bertalanffy) for anchovy in GSA 22.

	Fast growth Unsexed	Units
Linf	191	cm
K	0.385	$year^{-1}$
t0	-1.559	year
a	0.00004	gr
b	3.1157	
M age 0	1.5	year-
M age 1	1	year-
M age 2	0.72	year-
M age 3	0.66	year-
M age 4	0.62	year-

5.46.1.3. Maturity

The following maturity at age ogive was used for assessments in GSA 22 estimated from biological sampling and the DEPM surveys (Somarakis *et al.*, 2004; 2007). Length at first maturity is estimated approximately at 105 mm (Somarakis, 1999; Somarakis *et al.*, 2004; 2007) in Aegean Sea. The anchovy spawning period in GSA 22 extends from May to August with a peak in June-July. The major spawning grounds of anchovy in the Aegean Sea are located in areas characterized by wide continental shelf and enrichment processes associated with the outflow from large rivers or the Black Sea Water (BSW) in the northern Aegean Sea. Consequently, the highest egg densities have been typically observed over the northern Aegean Sea continental shelf.

Tab. 5.46.1.3.1 Maturity ogives at age for female anchovy in GSA 22.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2003	0	0.62	0.99	1	1
2004	0	0.67	0.99	1	1
2005	0	0.46	0.98	1	1
2006	0	0.40	0.98	1	1
2007	0	0.40	0.98	1	1
2008	0	0.40	0.98	1	1

5.46.2. Fisheries

5.46.2.1. General description of fisheries

Anchovy (*Engraulis encrasicolus*) is one of the most important target species for the purse seine fishery in GSA 22. Anchovy is being exploited only by the purse seine fishery. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Commonly anchovy is caught from shallow waters about 30 m to 100 m depth.

5.46.2.2. Management regulations applicable in 2009 and 2010

Regarding the management regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore (300 m), minimum bottom depth (30 m), gear and mesh size, engine, GRT restrictions etc. There is also a minimum landing size at 9 cm.

5.46.2.3. Catches

5.46.2.3.1. Landings

The trend in reported landings (from Greek purse seiners fleet) is shown in Figs. 5.46.2.3.1.1 and 5.46.2.3.1.2. Landings were obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22. The data from 2003 to 2008 were reported through the Data Collection Regulation. An increasing trend in anchovy landings has been observed (Fig. 5.46.2.3.1.1). Data of the landings per vessel class indicate that small vessels (12-24 m) (Fig. 5.46.2.3.1.2) are mainly responsible for anchovy catches (>70% of anchovy catches).

Annual lengths of landings were reported for 2003-2008 and are shown in Fig. 5.46.2.3.1.3. No data on the age distribution of landings was reported to the SGMED-10-02, through the DCR. Fig. 5.46.2.3.1.4 shows the landings at age in GSA 22 as reported to SGMED-08-04 for 2003-2006. Data for 2007 and 2008 are based on data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22.

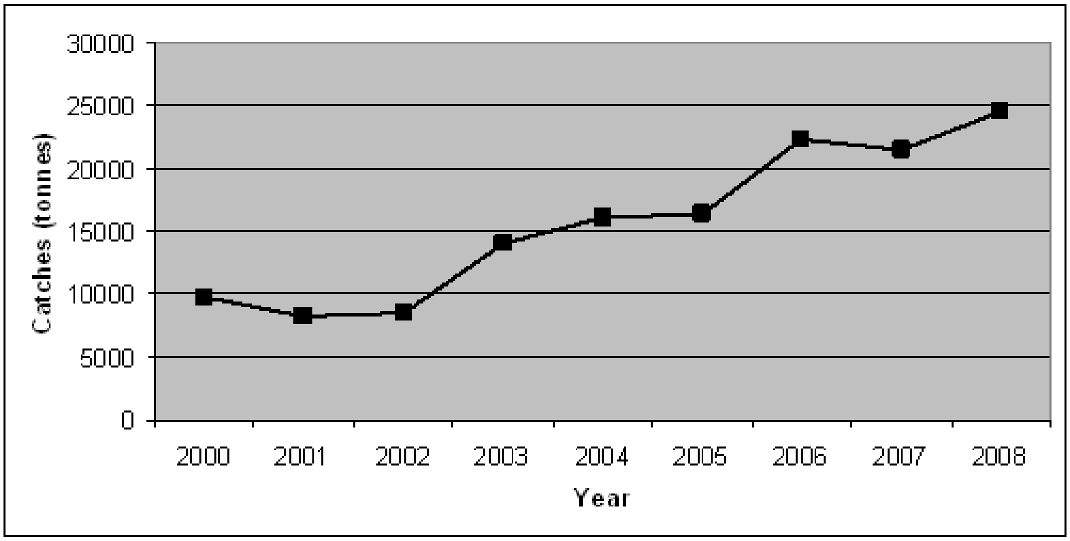


Fig. 5.46.2.3.1.1 Anchovy landings (t) in GSA 22 for 2000-2008.

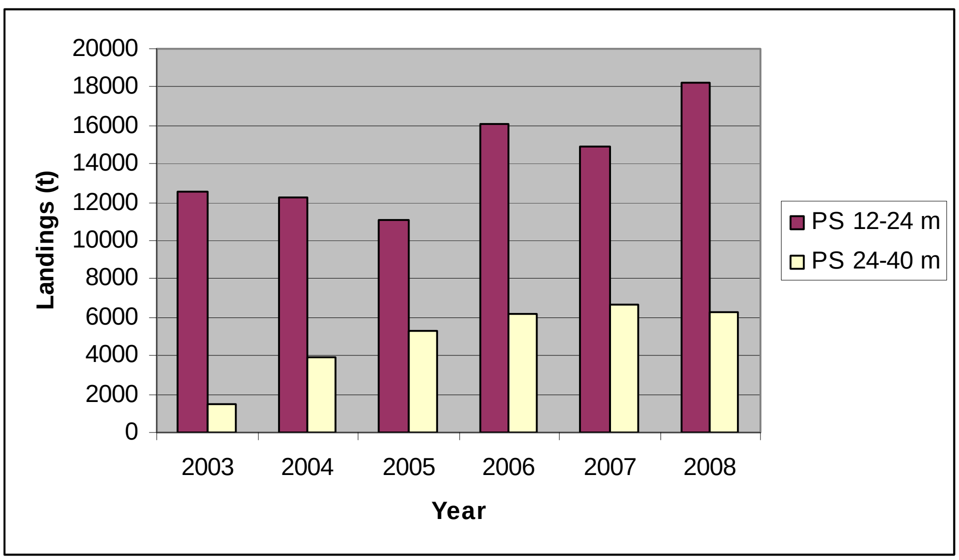


Fig. 5.46.2.3.1.2 Anchovy landings (t) in GSA 22 per fleet size (Greek waters).

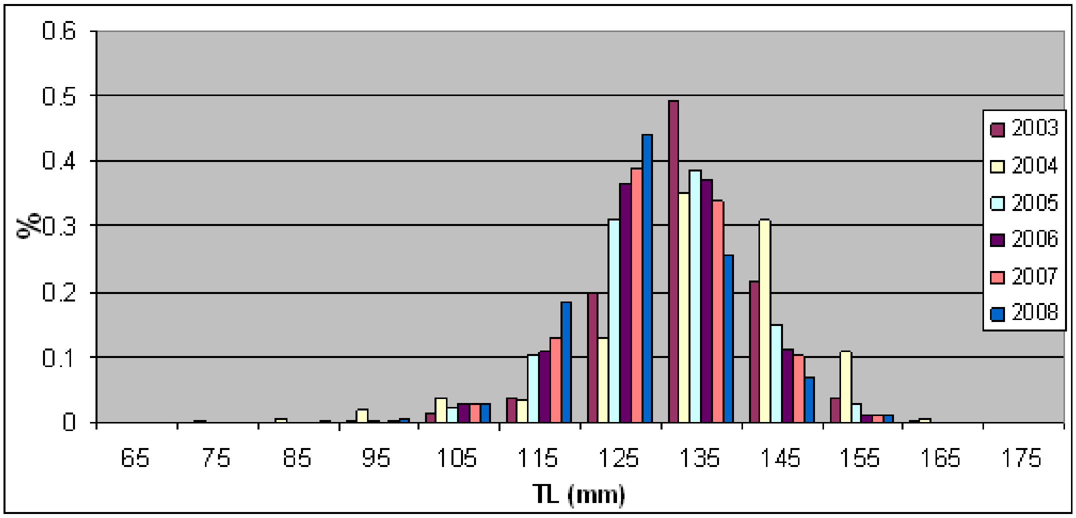


Fig. 5.46.2.3.1.3 Length frequency distribution of anchovy landings (t) in GSA 22 for 2003-2008.

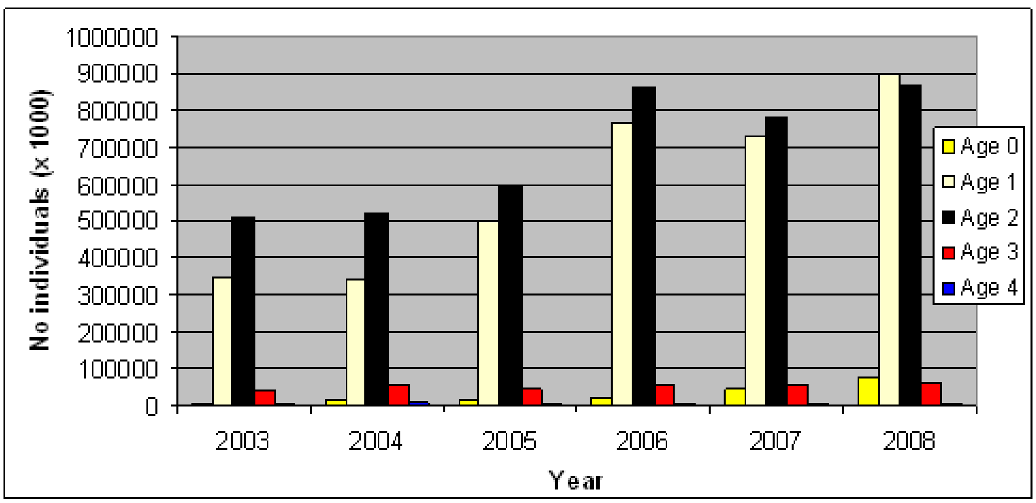


Fig. 5.46.2.3.1.4 Anchovy landings per age group (number of individuals in thousands) in GSA 22 for 2003-2008.

5.46.2.3.2. Discards

No discards data for anchovy were reported to the SGMED-09-02 and no data were reported through the Data collection regulation for 2003-2008. According to data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22, discards are estimated to less than 1%, consisting 0.06% of the purse seine fishery total catch. Although considered negligible they were taken into account for the assessment as a percentage to reported landings. The fishery is multispecies and fishermen tend to avoid schools of undersized anchovies due to sorting difficulties (blocking of the mesh) and low price, practically by using nets of bigger mesh size, targeting mostly mackerels or horse mackerels.

5.46.2.3.3. *Fishing effort*

Based on the fishing effort data reported through the Data collection regulation and data obtained within the framework of the Hellenic Centre for Marine Research data collection system covering the entire GSA 22, the following table was made:

Tab. 5.46.2.3.3.1 Effort data for the purse seine fleet in GSA 22 (GT=Gross tonnage, KW=engine power).

Year	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m
	Days at Sea	**Days at Sea**	**Days at Sea x GT**	**Days at Sea x GT**	**Days at Sea x KW**	**Days at Sea x KW**
2003	41539	2942	1767398	230726	8709727	679624
2004	39783	3989	1620847	366709	8111571	1029410
2005	42520	5690	1753346	542120	8123673	1532790
2006	37255	5619	1568893	539146	7386042	1606608
2007	31492	5338	1305252	524544	6511187	1528440
2008	35090	4938	1457212	473121	6898061	1335582

5.46.3. *Scientific surveys*

5.46.3.1. Acoustics and DEPM

5.46.3.1.1. *Methods*

Acoustics

Based on data reported to SGMED-09-02 total biomass, abundance, length and age composition for GSA 22 were estimated by acoustics from 2003 to 2008. No age distribution data were reported through the DCR for 2008. No acoustic survey took place in 2007.

Acoustic surveys methodology

Acoustic echoes were registered continuously along 70 pre-defined transects in the study area in June 2003, 2004, 2005, 2006 and 2008 with a Biosonics Split Beam 38 kHz DT-X echosounder. The acoustic methodology followed is described in Somarakis *et al.* (2007) (GFCM 2007 related WD). Hydroacoustic data analysis was performed using the Sonardata Echoview software v3.30. Echo trace classification was applied based on a) echogram visual scrutinisation and direct allocation of school marks that characterise anchovy as well as b) allocation on account of representative fishing stations that were held along transects (MacLennan and Simmonds, 1992).

In order to estimate anchovy biomass, the length-weight relationship is required as well as species length frequency distribution per area. Therefore, 22, 23, 27, 37 and 30 pelagic trawls were made along transects in 2003, 2004, 2005, 2006 and 2008 respectively, in the positions of high fish concentrations. A random sample of 200 specimens was obtained from each haul for further laboratory analysis. Subsequently, the length-weight relationship was estimated from the total number of hauls according to the equation:

$$W = a\, L^b$$

where W is the total weight; L is the total length and a and b are constants that are estimated by regression analysis.

The mean length frequency was estimated in two sub-areas: (a) Eastern area (Thracian Sea and Strymonikos Gulf) and (b) Western area (Thermaikos and Evoikos Gulfs). In the two sub-areas, the mean frequency of each length class was estimated as follows:

$$f_j = \frac{\sum_{k=1}^{M}\left(\frac{n_{jk}}{t_k}\right)}{\sum_{k=1}^{M}\left(\frac{N_k}{t_k}\right)}$$

where f_j is the mean frequency of anchovy of length class j; n_{jk} is the number of specimens of length class j in haul k; N_k is the total number of anchovies in haul k; t_k is the duration of haul k and M is the number of hauls in the area. The above equation is appropriate even if the catches are small and the length distributions are poorly defined. It takes accounts of the haul duration, since it is supposed that on average, longer hauls will produce more fish (MacLennan and Simmonds, 1992).

The density of targets (F) from the observed echo integrals were estimated according to the equation $F=(K/\langle\sigma\rangle)E$, were K is the calibration factor, $\langle\sigma\rangle$ is the mean cross-section and E is the echo integral after partitioning (MacLennan and Simmonds, 1992). The target strength (TS) – total length relationship used for anchovy was: TS=20 logL-71.2, where L is fish total length (ICES, 2006). The $\langle\sigma\rangle$ was calculated for the mean total fish length of each area according to the equations $\langle\sigma\rangle = 4\pi\sum_{\iota} f_i 10^{TS/10}$, where f_I is the corresponding length frequency as deduced from the fishing samples (MacLennan and Simmonds, 1992).

The abundance Q was estimated separately for the eastern and the western part of the study area. The abundance Q in each elementary statistical sampling area was calculated from the average density within each sub-area according to the equation:

$$Q = A_k \sum_i F_i / N_k,$$

where F_i is the i sample; A_k is the area of each elementary statistical sampling area and N_k is the number of transects in A_k. The variance V was estimated as

$$V = \sum_i (AF_I - Q)^2/[N_r(N_{r-1}-1)]$$

The data were log transformed and the means and variances of F estimated according to the following equations:
$F=\exp(m)\mathbf{G_N}[0.5\ S/(n-1)$; $V=F^2-\exp(2m)\ \mathbf{G_N}[S(n-2)/(n-1)^2]$;
where m = average (lnF); S= variance (lnF) and n = independent observations of F.
The total abundance Q_t and its variance were obtained by summing the results for each region $Q_t=Q_1+Q_2+\dots$, and $V_t=V_1+V_2+\dots$. Standard error of Q_t is the square root of V (MacLennan and Simmonds, 1992).

Daily Egg Production surveys (DEPM) methodology

The methodology of the DEPM is described in detail in Somarakis *et al*. (2007) GFCM WD. The spawning stock biomass was estimated according to the model described by Parker (1980) and subsequently modified by Stauffer & Picquelle (1980):

$$B = (k \cdot P \cdot A \cdot W)/(R \cdot F \cdot S)$$

where, B = spawning stock biomass in metric tons, k = conversion factor from grams to metric tons, P = daily egg production (number of eggs per sampling unit, m^2), A = total survey area (in sampling units, m^2), W = average weight of mature females (grams), R = sex ratio (fraction of mature females by weight), F = batch fecundity (mean number of eggs per mature females per spawning), S = fraction of mature females spawning per day (spawning frequency).

5.46.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.46.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the anchovy stock in GSA 22 was derived from the acoustics and the DEPM surveys. Figure 5.46.3.1.3.1 displays the estimated trend in anchovy Total Biomass (estimated by acoustics) and Spawning Stock Biomass (estimated by DEPM) for GSA 22. Figure 5.46.3.1.3.2 shows the estimated trend in anchovy abundance (estimated by acoustics).

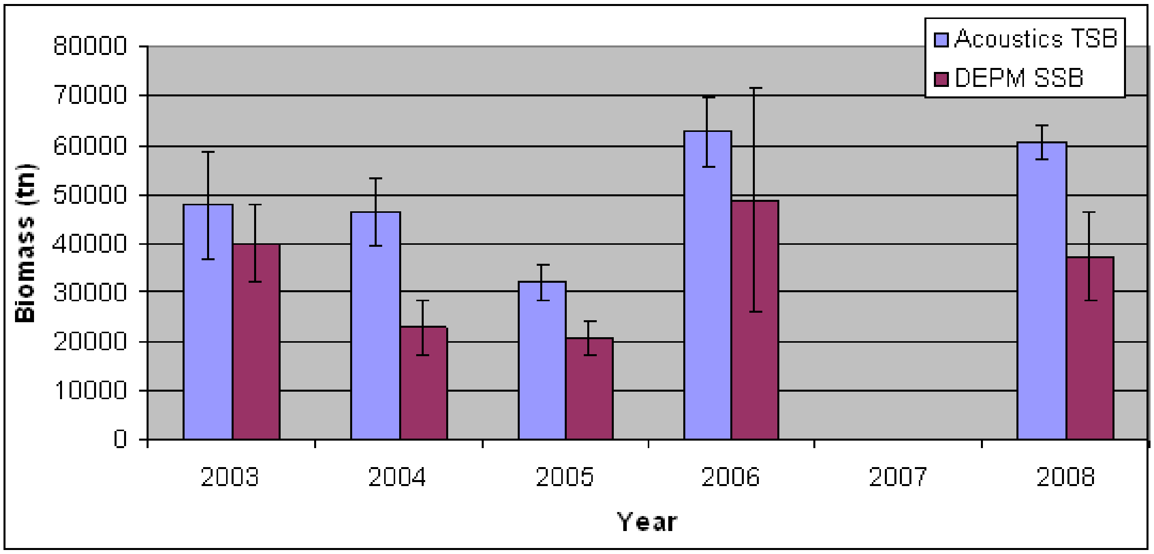


Fig. 5.46.3.1.3.1 Estimated anchovy biomass indices for GSA 22, 2003-2006 and 2008.

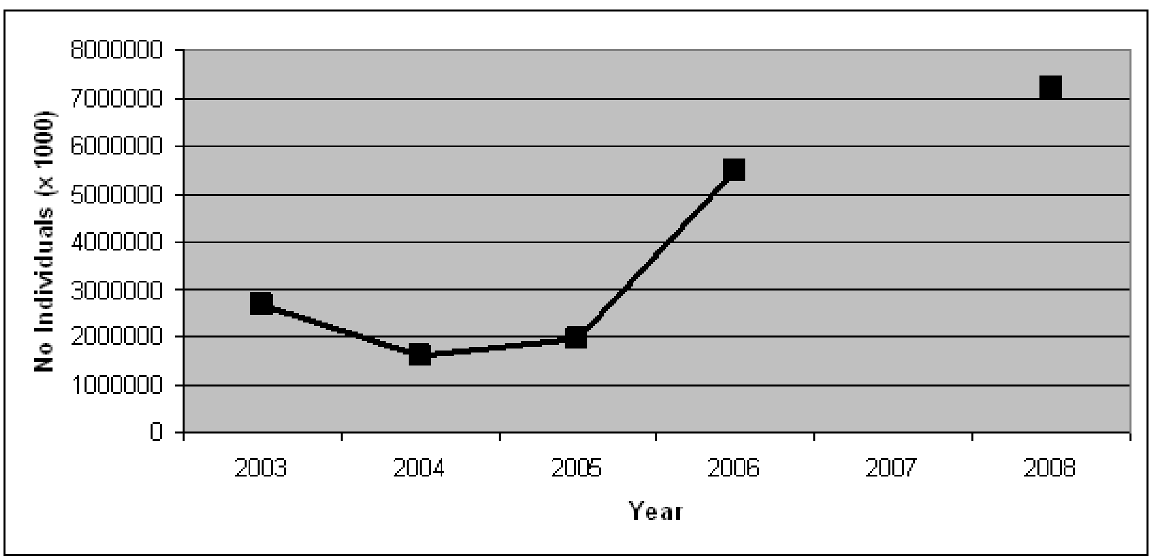


Fig. 5.46.3.1.3.2 Estimated abundance indices for GSA 22, 2003-2006 and 2008.

An increasing trend was observed in both biomass and abundance indices (Fig. 5.46.3.1.3.1, Fig. 5.46.3.1.3.2).

5.46.3.1.4. Trends in abundance by length or age

Figure 5.46.3.1.4.1 shows the length frequency composition of the anchovy stock as derived from the acoustic surveys in GSA 22.

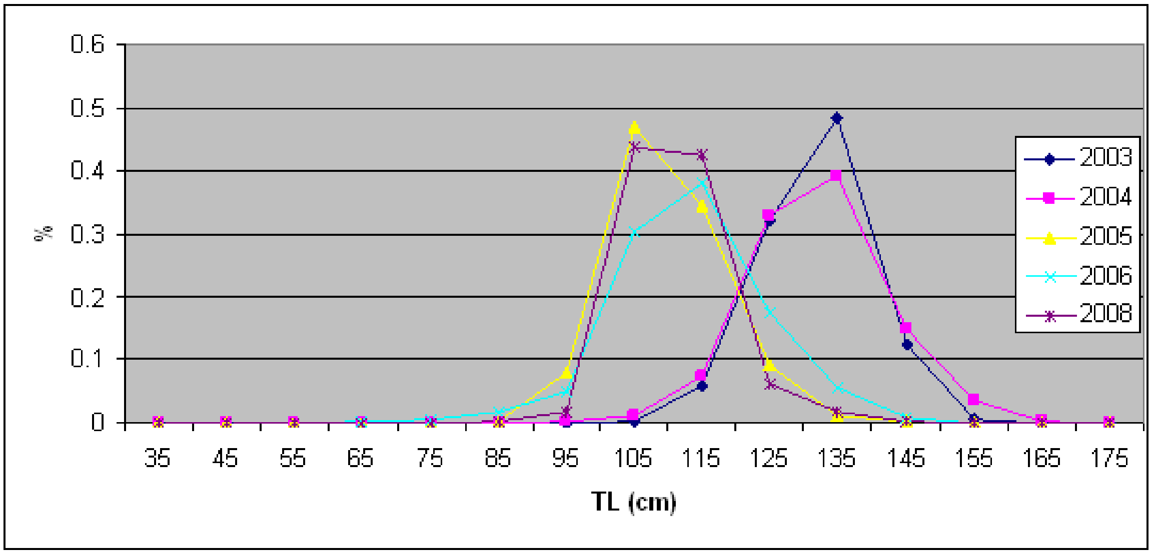


Fig. 5.46.3.1.4.1 Estimated changes in size compositions for GSA 22 for 2003-2006 and 2008.

The following Fig. 5.46.3.1.4.2 and Fig. 5.46.3.1.4.3 show the abundance indices by size and age of GSA 22 for 2003-2006 and 2008 based on acoustic surveys.

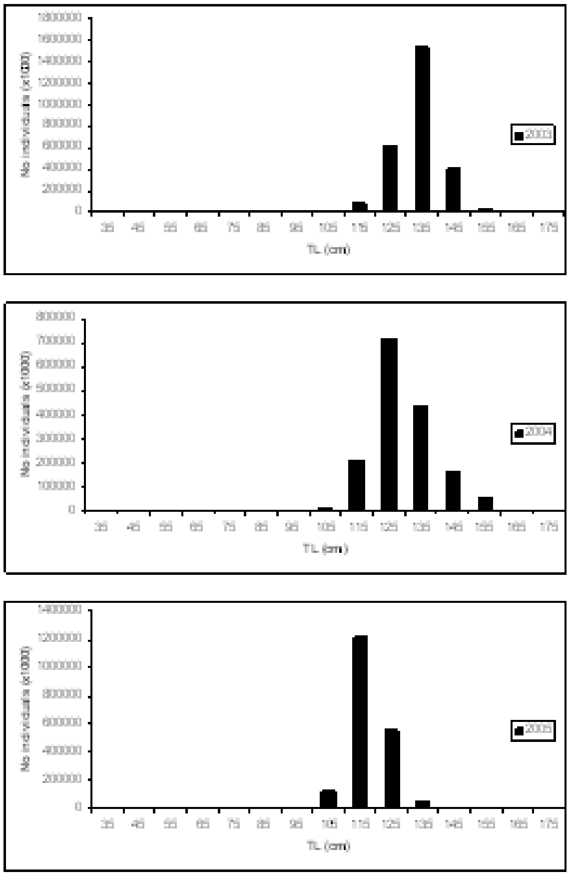


Fig. 5.46.3.1.4.2. Abundance indices by size for 2003-2006 and 2008.

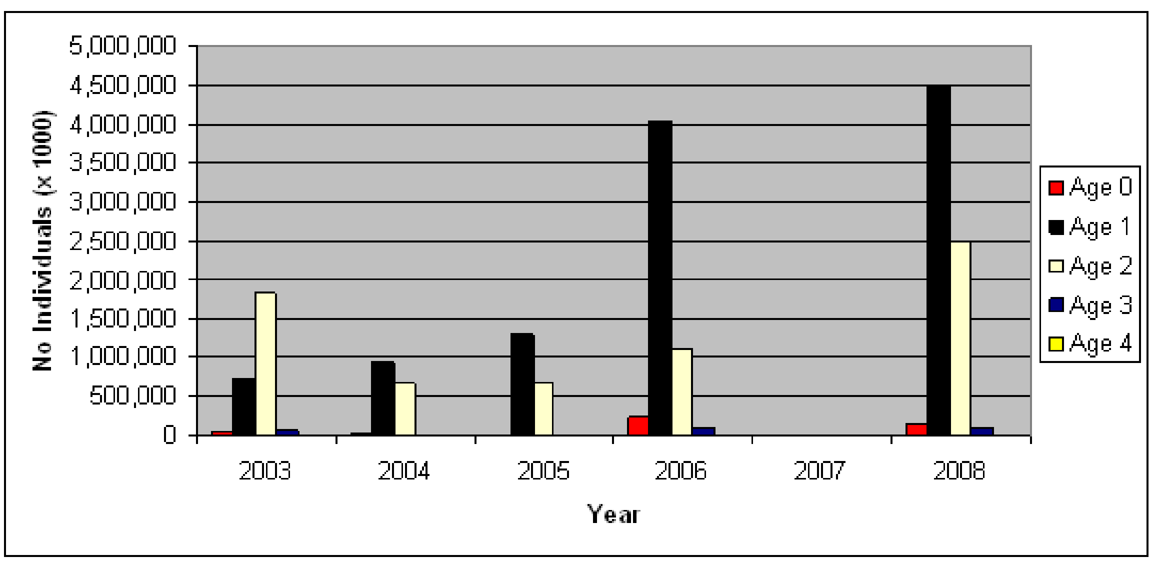


Fig. 5.46.3.1.4.3. Abundance indices by age for 2003-2006 and 2008.

5.46.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02. Growth equation was supplied through DCR in 2009 and it was estimated based on aggregated data collected in GSA 22 for the period 2003 to 2008.

5.46.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02. Maturity ogive based on the results of the DEPM surveys was used (Table 5.46.3.1.6.1).

Tab. 5.46.3.1.6.1. Maturity ogive for anchovy in GSA 22 based on the results of DEPM surveys.

Age	2003	2004	2005	2006	2008
0	0	0	0	0	0
1	0.62	0.67	0.46	0.4	0.4
2	0.99	0.99	0.98	0.98	0.98
3	1	1	1	1	1
4	1	1	1	1	1

5.46.4. Assessment of historic stock parameters

5.46.4.1. Method: ICA

5.46.4.1.1. Justification

Integrated Catch at Age (ICA) analysis for stock assessment (Patterson and Melvin, 1996) was applied. Integrated Catch at age analysis uses separable virtual population analysis (VPA) (Pope & Shepherd, 1985) with weighted tuning indices. It was applied regarding the Aegean anchovy stock during the SGMED-09-02 as an update of the one adapted in the SGMED-08-04 report (Cardinale *et al*., 2008). This assessment of the anchovy stock in GSA 22 is based on a short time series of available, so results should be considered with caution. In addition Y/R analysis was applied during the SGMED-09-02.

5.46.4.1.2. Input parameters

ICA was based on commercial catch data (2000-2008). Biomass estimates from acoustic surveys over the period 2003-2006 and 2008 and Daily Egg Production Method (DEPM) estimates were used as tuning indices. Anchovy data concerned annual anchovy landings, annual anchovy catch at age data (2000-2008), mean weights at age, maturity at age and the results of acoustic and DEPM surveys (2003-2006 and 2008) presented in Tables 5.46.4.1.2.1 to 5.46.4.1.2.7. Age-Length-Key was applied on a six month basis to convert length distribution into age distribution. In addition discards were taken into account. Specifically, according to data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22, discards are estimated to less than 1%, consisting 0.06% of the purse seine fishery total catch. Although considered negligible they were taken into account for the assessment as a percentage to reported landings.

Since, acoustics and DEPM are being applied at the same time and with the same research vessel in Aegean Sea, acoustic estimates were used as an index for the numbers at age of the population and DEPM estimates as stock spawning biomass estimates. Reference age for the fishery was age group 2, as fully exploited and fully recruited. Eight years separability was selected.The age groups 0, 4 and 5 were underweighted in the analysis based on their percentage in the catch. Age 1 was also underweighted in the acoustic surveys (0.5). Catchability for the DEPM index is assumed as absolute indicator of Biomass, linear catchability relationship is assumed for the acoustic surveys. Different natural mortality values were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. This method for estimating natural mortality is consistent with the methodology used in GSAs 05, 06 and 17 for small pelagics. Average values of maturity ogive and weight at age in the stock were used for 2007.

Tab. 5.46.4.1.2.1. Catch at age (numbers in thousands) of anchovy stock in GSA 22 for 2000-2008.

Year	0	1	2	3	4
2000	8859	287419	357849	27449	2160
2001	14506	286470	297203	19457	1000
2002	9803	304095	328428	23198	1269
2003	4676	348900	513289	41899	3881
2004	16315	342761	521446	57843	8527
2005	14523	498088	591543	43454	3003
2006	21930	766824	863957	57795	6472
2007	46515	731249	782267	58787	5727
2008	75828	892863	866883	64421	2531

Tab. 5.46.4.1.2.2. Catch estimates (in t) of anchovy stock in GSA 22 for 2000-2008.

Year	Anchovy
2000	10348
2001	8726
2002	9063
2003	14843
2004	17064
2005	17327
2006	24461
2007	22791
2008	25950

Tab. 5.46.4.1.2.3. Weight at age in the catch of anchovy stock (in kg) in GSA 22 for 2000-2008.

	Year								
Age	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	0.0085	0.0093	0.0098	0.0057	0.0029	0.0036	0.0099	0.0102	0.0105
1	0.0125	0.0134	0.0133	0.0164	0.0146	0.0096	0.0151	0.0139	0.0127
2	0.0138	0.0151	0.015	0.0184	0.0184	0.0137	0.0161	0.0153	0.0146
3	0.0145	0.0161	0.0161	0.0188	0.0204	0.016	0.0174	0.0176	0.0179
4	0.0245	0.0297	0.0257	0.0398	0.0338	0.0334	0.0187	0.0223	0.0258

Tab. 5.46.4.1.2.4. Weight at age in the stock (in kg) of anchovy stock in GSA 22 for 2000-2008.

	Year								
Age	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	0.005	0.005	0.005	0.0057	0.0033	0.0014	0.0017	0.0016	0.0015
1	0.0011	0.0011	0.0011	0.0058	0.0086	0.0056	0.0067	0.0083	0.0098
2	0.0136	0.0136	0.0136	0.0201	0.0201	0.0147	0.0191	0.0167	0.0143
3	0.0153	0.0153	0.0153	0.0293	0.0224	0.0246	0.0231	0.0219	0.0207
4	0.0179	0.0179	0.0179	0.0398	0.0338	0.0334	0.0209	0.0227	0.0245

Tab. 5.46.4.1.2.5. Maturity ogive of anchovy stock in GSA 22 for 2003-2008.

Year	0	1	2	3	4
2003	0	.62	.99	1	1
2004	0	.67	.99	1	1
2005	0	.46	.98	1	1
2006	0	.40	.98	1	1
2007	0	.40	.98	1	1
2008	0	.40	.98	1	1

Tab. 5.46.4.1.2.6. Spawning biomass indices (SSB in t) of anchovy stock in GSA 22 for 2003-2008.

Year	SSB
2003	40042
2004	22799
2005	20533
2006	48700
2007	-
2008	37404

Tab. 5.46.4.1.2.7. Age-structure indices of anchovy stock (numbers in thousands) in GSA 22 for 2003-2008. Age 3 was considered a plus age group.

Age	2003	2004	2005	2006	2007	2008
1	711816	925773	1291270	4044093	-1	4469332
2	1822817	667953	663465	1109500	-1	2495923
3+	69679	5177	7524	99442	-1	95920

5.46.4.1.3. Results including sensitivity analyses

The graphical diagnostics of the model shown in Figs. 5.46.4.1.3.1 to 5.46.4.1.3.5, generally showed good model fit besides year 2002 and age 4, probably because they are poorly sampled. This further justifies the down weighting of age 4 in the model. Residual plots for recent years showed no strong deviations from separability. SSQ plot (Fig. 5.46.4.1.3.6) indicated moderate consistency between the model and the indices (minima fairly close to each other on x-axis, Needle (2000)).

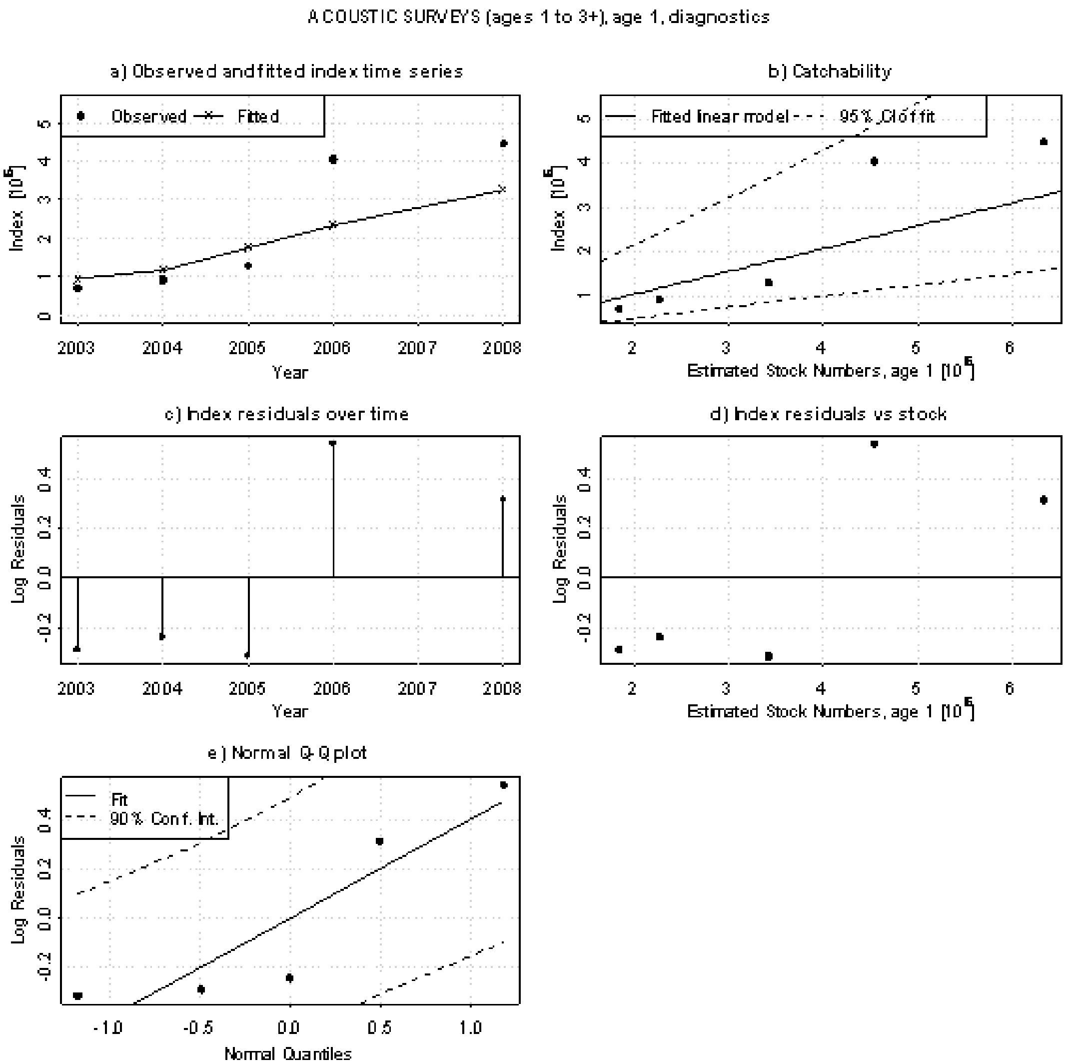


Fig. 5.46.4.1.3.1 Residual plots for age 1 indices of anchovy ICA model for GSA 22 (2003-2008).

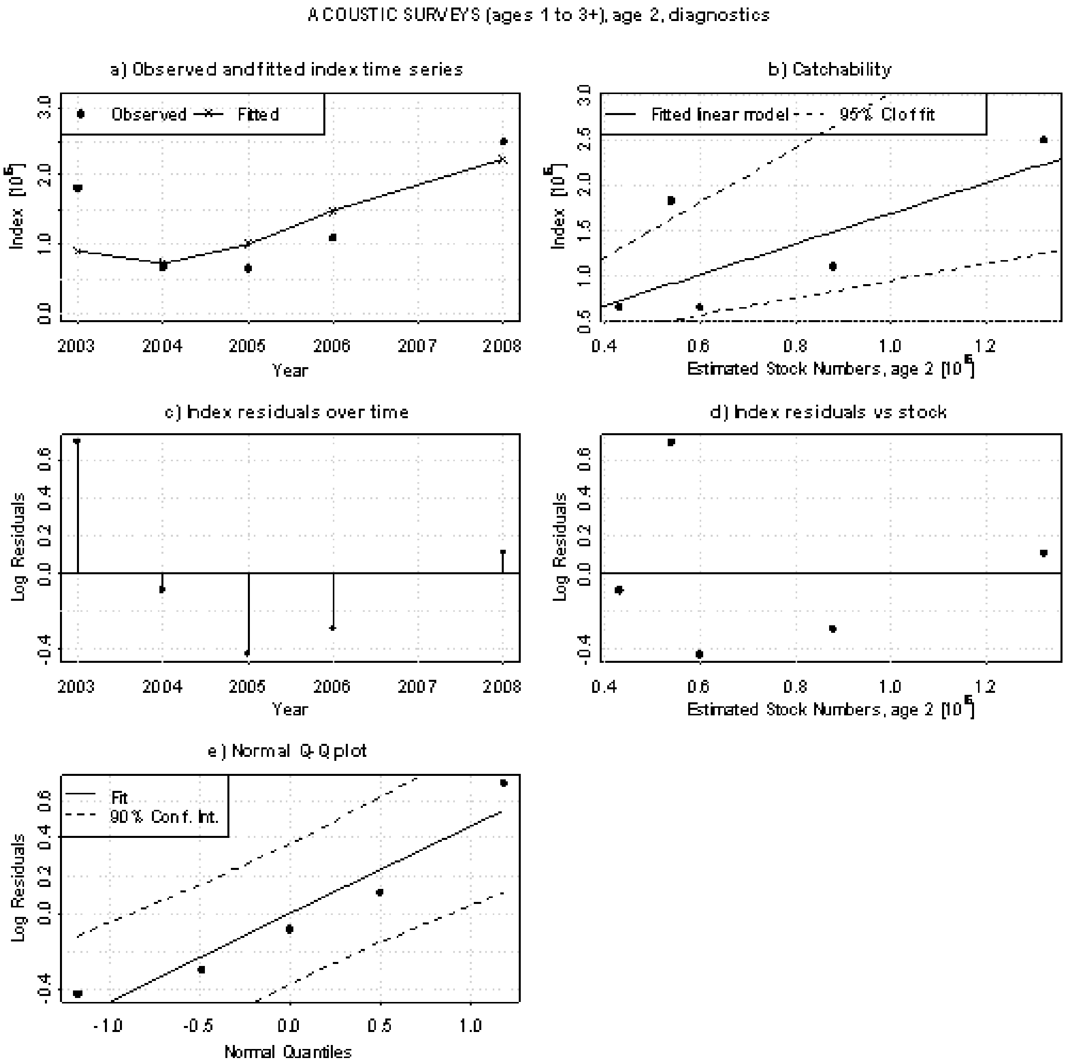


Fig. 5.46.4.1.3.2 Residual plots for age 2 indices of anchovy ICA model for GSA 22 (2003-2008).

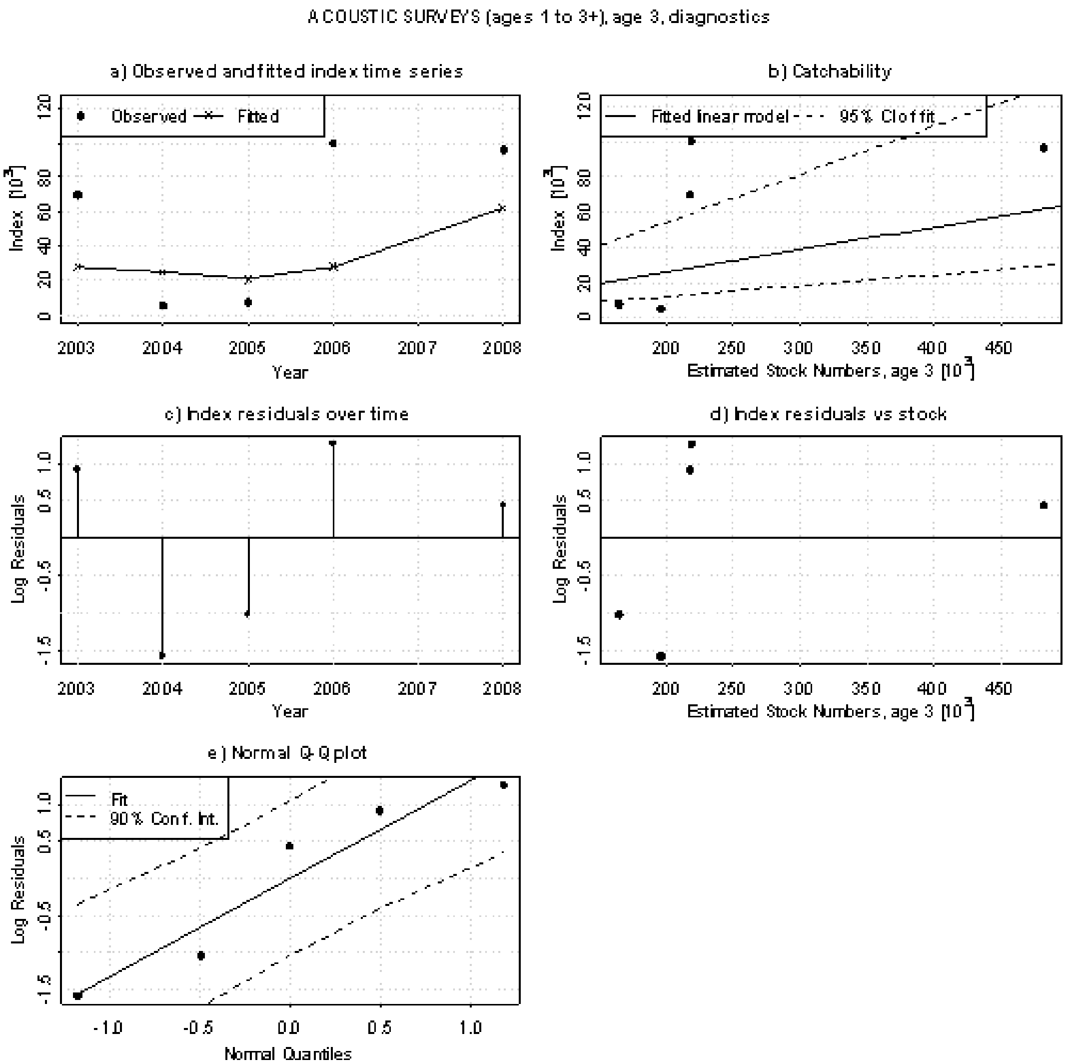


Fig. 5.46.4.1.3.3 Residual plots for age 3 indices of anchovy ICA model for GSA 22 (2003-2008).

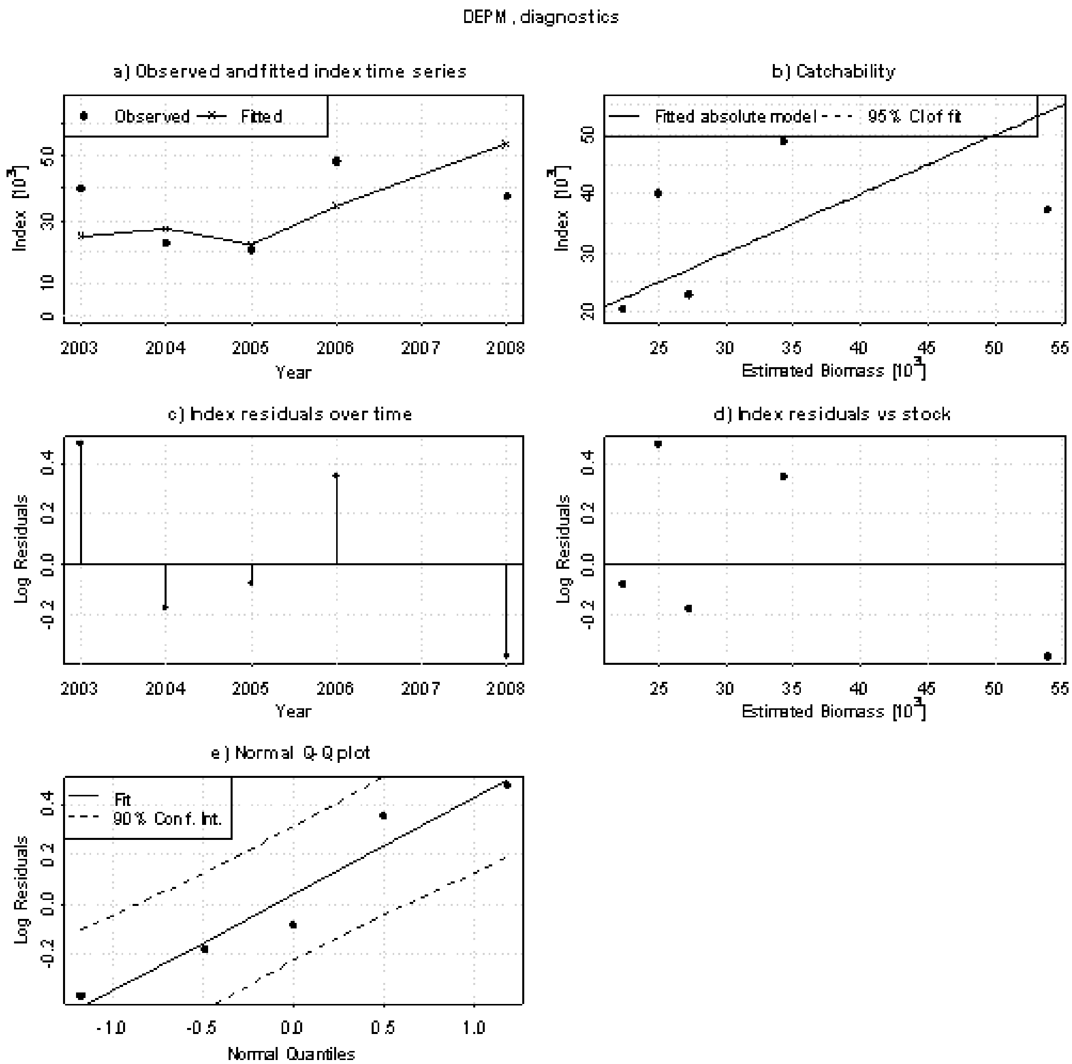


Fig. 5.46.4.1.3.4 Residual plots for SSB indices of anchovy ICA model for GSA 22 (2003-2008).

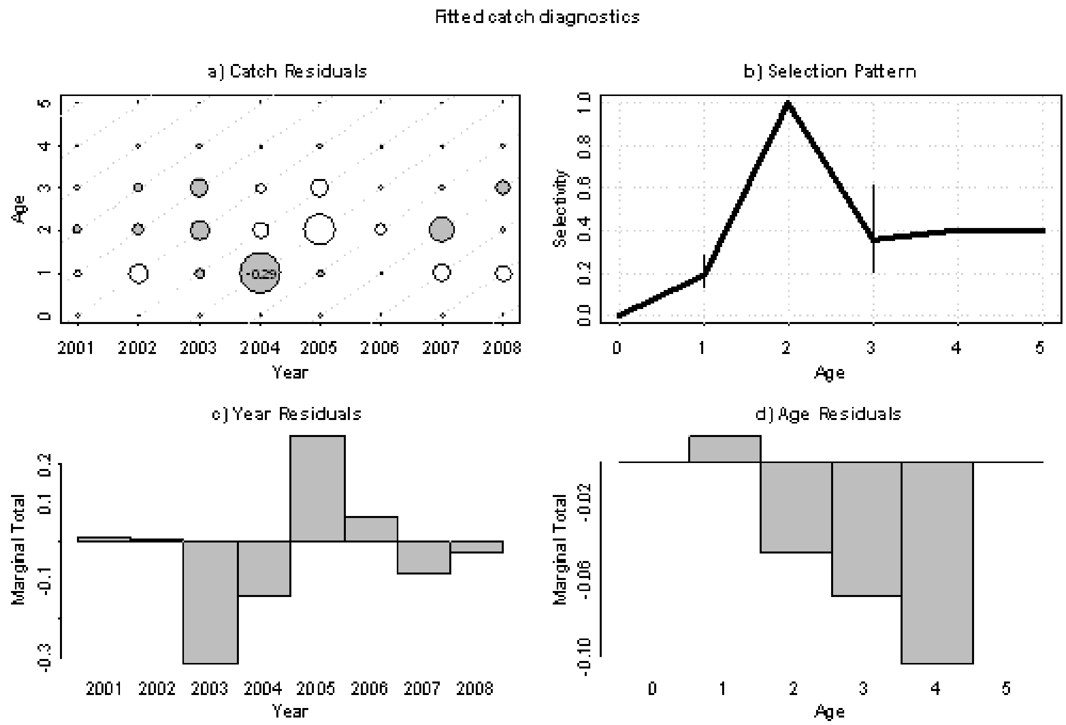


Fig. 5.46.4.1.3.5 The catch at age residuals plots for catch of anchovy ICA model for GSA 22 (2001-2008).

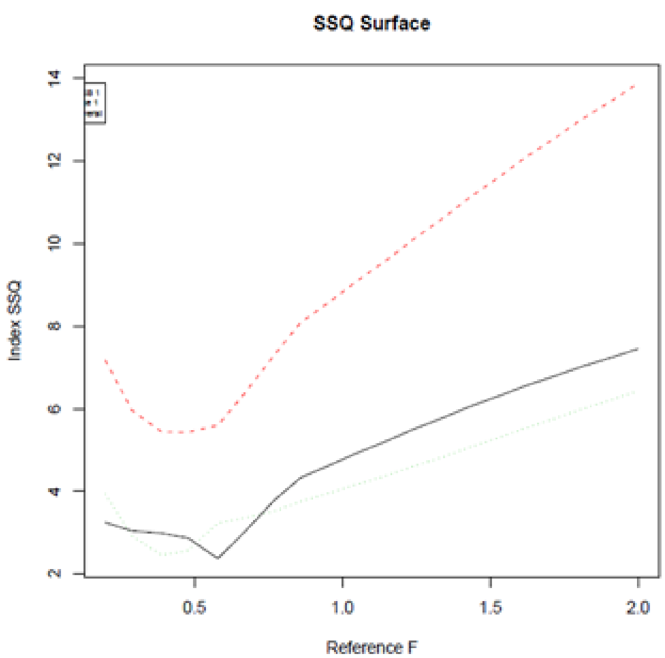


Fig. 5.46.4.1.3.6 Sum of Squares (SSQ) surface plot of the Anchovy ICA Model.

ICA model results for anchovy stock in GSA 22 are shown in Fig. 5.46.4.1.3.7, indicating an increasing trend for recruitment since 2004 with a pronounced increase for 2008. However this is probably an overestimation of the last year as the model predicts a decrease at the level of 2006 for 2009. An increase in biomass has also been observed since 2005. Average fishing mortality for ages 1 to 3 (which are target ages for the fishery) shows a decrease since 2004. The landings to total biomass ratio also decreases, approximating on average less than 10% based on model results in 2008. Similarly, the landings to SSB ratio also decreases, approximating on average 40% based on model results in 2008.

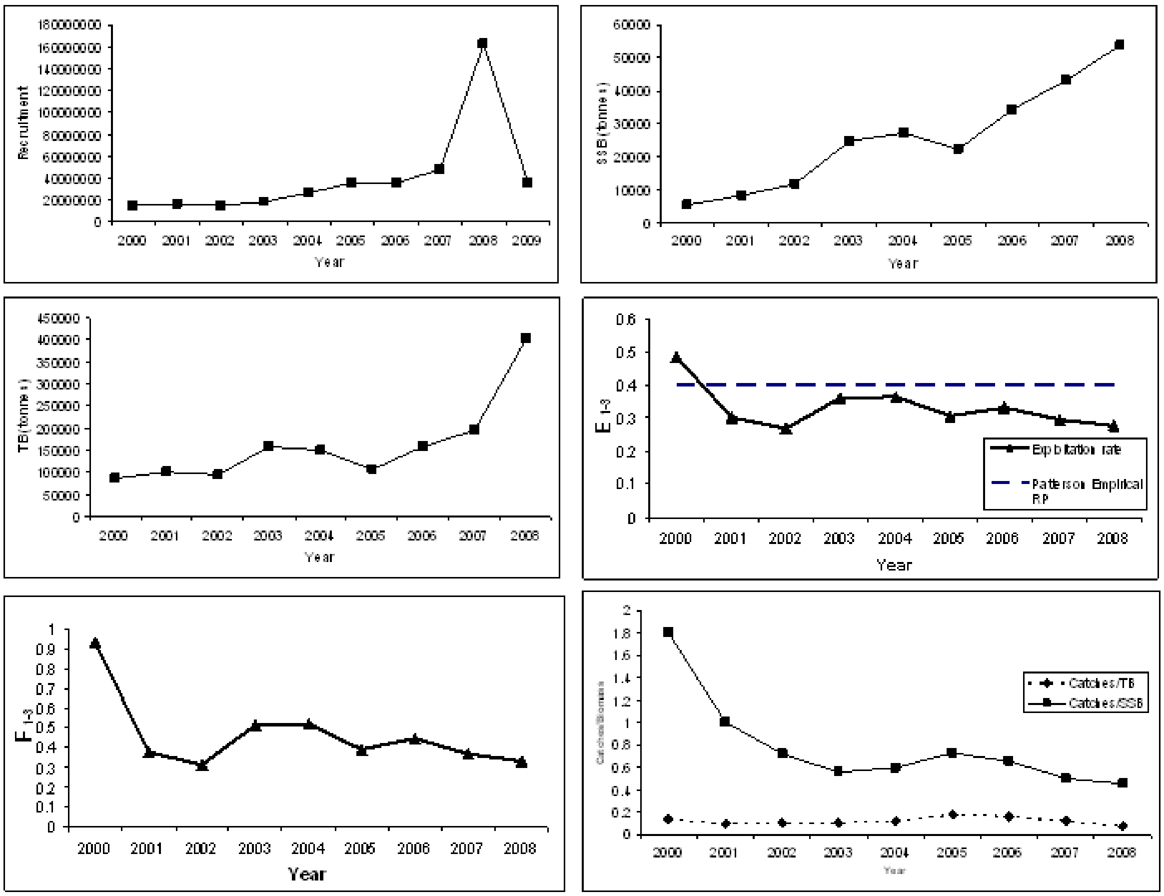


Fig. 5.46.4.1.3.7 Anchovy ICA Model results: Recruitment, SSB, Total biomass, exploitation rate (F/Z), F mean for ages 1-3, landings to biomass ratio.

Retrospective analysis was applied in the ICA model for the Aegean anchovy 2000-2008 with one year backward analysis. Applying the analysis with more than one year backward was not possible due to the short time series available. Results are presented in Fig. 5.46.4.1.3.8, showing no particular retrospective bias and consistency in the beginning of the time series.

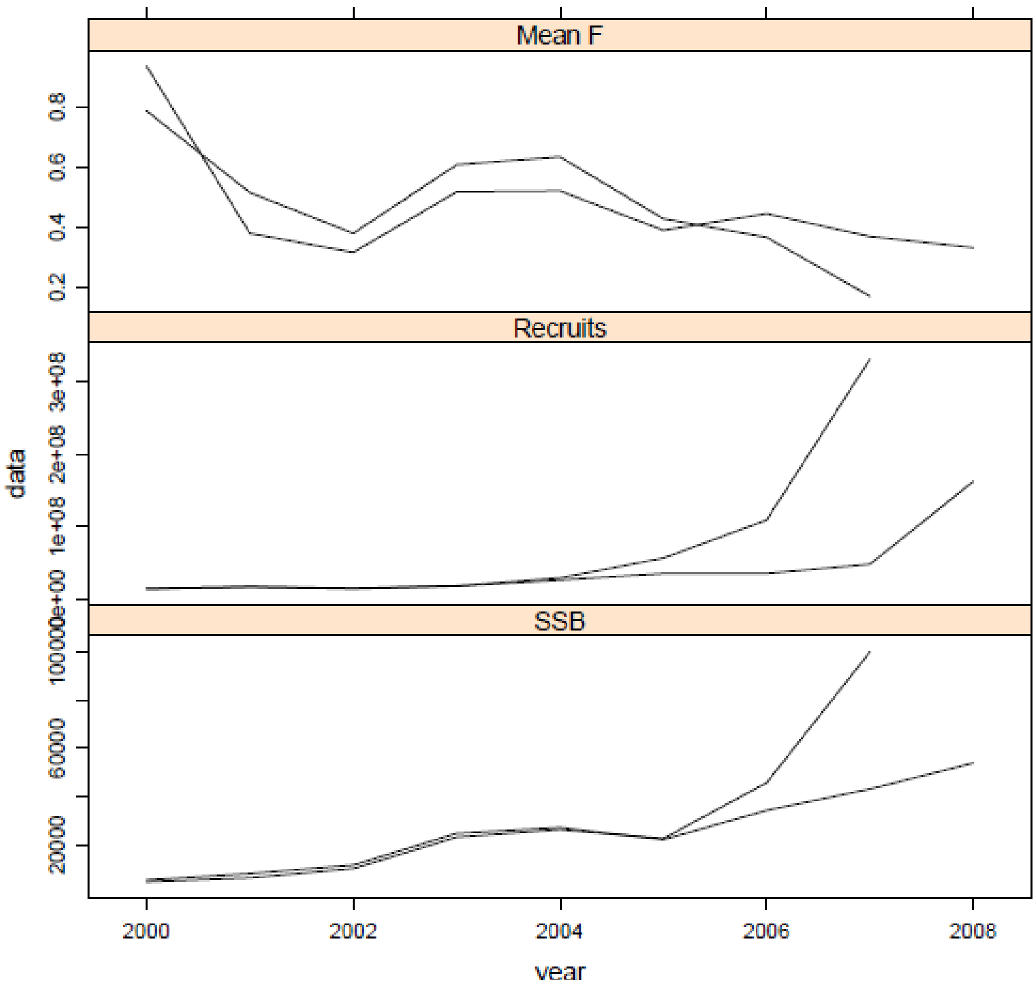


Fig. 5.46.4.1.3.8 The results of retrospective analysis in the Aegean Sea anchovy ICA model 2000-2008, concerning F mean 1-3, SSB and recruitment.

5.46.5. Long term prediction

5.46.5.1. Justification

Yield per recruit analysis was conducted in the SGMED-09-02 assuming equilibrium conditions.

5.46.5.2. Input parameters

Yield per recruit analyses was conducted based on the exploitation pattern resulting from the ICA model and population parameters, Minimum and maximum age for the analysis were considered to be age group 0 and 4, respectively. Stock weight at age, catch weight at age and maturity ogive were estimated as mean values on a long term basis (2000-2008). Different natural mortality values were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Fishing mortalities were estimated in a short term basis (2004-2008). Reference F was considered to be mean F for ages 1 to 3. Input parameters are shown in Table 5.46.5.2.1.

Tab. 5.46.5.2.1. Input parameters for Y/R analysis.

age group	stock weight	catch weight	maturity	F	M
0	0,003	0,008	0	0,0011	1,50
1	0,005	0,014	0.51	0,1561	1,00
2	0,016	0,016	0.98	0,8291	0,74
3	0,021	0,017	1	0,4169	0,66
4	0,025	0,028	1	0,3744	0,62

5.46.5.3. Results

Y/R analyses were performed (Fig. 5.46.5.3.1) but were not considered reliable due to its flat-topped shape. Therefore,$F_{0.1}$ (1.44) cannot be used as a reference point for this stock.

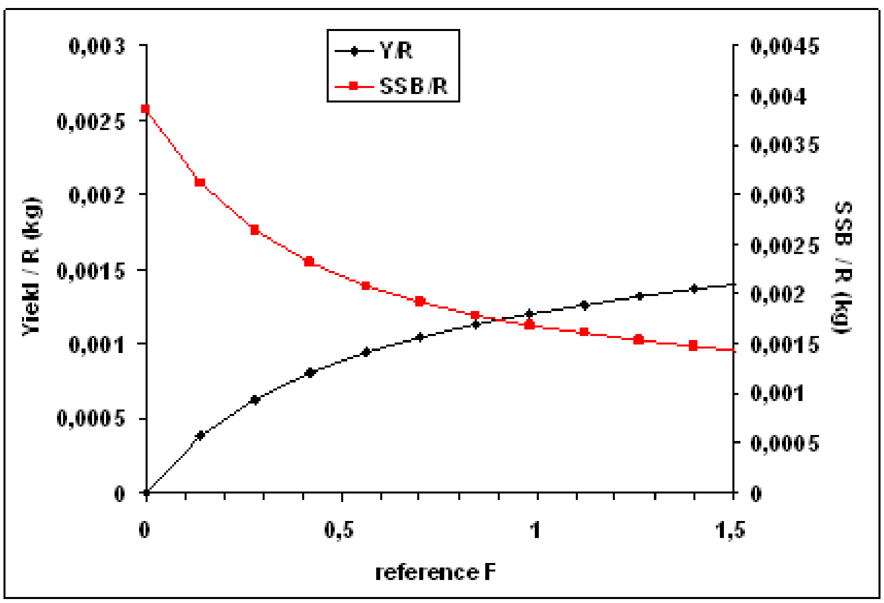


Fig. 5.46.5.3.1. Yield per recruit for the anchovy stock in GSA 22.

5.46.6. Scientific advice

5.46.6.1. Short term considerations

5.46.6.1.1. State of the spawning stock size

Estimates of fishery independent surveys for anchovy in GSA 22 indicated a slight increase from lower levels in 2005 to the most recent estimates in 2006 and 2008 concerning both Total Biomass (62,604 t in 2006 and 60,600 t estimated by acoustics) and SSB (48,700 t in 2006 and 37,400 in 2008 t estimated by DEPM). Similarly, results of the Integrated Catch at Age analysis indicated an increasing trend in total biomass and in SSB showing an increase in 2008 from the lower level observed in 2005. The state of the spawning biomass in relation to precautionary limits cannot be evaluated since there are no reference points derived form the short series of data available. However the level of anchovy SSB in 2008 is well above the lowest SSB level (in 2005) observed.

It should be considered that this assessment is based on a short time series of data and not suitable to suggest reference points of B_{lim}. Moreover, anchovy is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends on environmental conditions.

5.46.6.1.2. *State of recruitment*

ICA model estimates had shown an increase in the number of recruits towards 2008. However the model predicts a decrease in 2009, similar to the 2006 level.

5.46.6.1.3. *State of exploitation*

Based on ICA results, the mean F (for ages 1 to 3) showed a decrease since 2003 with mean for 2000-2008 equal to 0.33 and, since 2004, is being well below the exploitation reference points (E<0.4, Patterson (1992)) suggested by SGMED as an appropriate target reference for small pelagics.

Furthermore, due to the high values of natural mortality used, Y/R analysis indicated no significant reduction in SSB at high values of F. Therefore the use of F_{max} and $F_{0.1}$ as a reference point was not considered appropriate. Precautionary the use of $F_{(E0.4)}$ that assures exploitation rate below the empirical level for stock decline (E<0.4, Patterson (1992)) for small pelagics was suggested by the SGMED-09-02 as exploitation reference point for this stock.

Based on this assessment results the stock is considered to be harvested sustainably, operating below but close to an optimal yield level, with no expected room for further increase in catch and effort. SGMED recommends that fishing effort should not increase beyond the current levels and consistent catches should be determined. This should allow maintaining the current levels of fishing mortality. However this has to be confirmed in following years and the anchovy stock should be monitored on an annual basis. Mixed fisheries implications, i.e. the interaction with sardine, need to be considered when managing this fishery.

For precautionary reasons the possibility of changing the closed period should be examined. Since the fishery is considered a multispecies targeting both anchovy and sardine, a shift of the closed period (present: mid December to end of February) towards the recruitment period of anchovy (e.g. October to December) / or the recruitment period of sardine (e.g. February to April) could be suggested allowing more individuals of anchovy and/or sardine to enter the fishery at an older age.

5.47. Stock assessment of sardine in GSA 01

5.47.1. Stock identification and biological features

5.47.1.1. Stock Identification

Little or no specific work has been conducted on the stock identification of sardine in the Western Mediterranean, but exchanges between the Northern Alboran Sea (GSA 01) with both the Northern Spain (GSA 06) and South Alboran Sea (GSA 03) are believed to be negligible. Based on the above considerations, STECF recommends continuing with the assessments on GFCM-GSA basis. Fig. 5.47.1.1.1. shows the GFCM Geographical Sub-Area GSA 01 (Northern Alboran Sea).

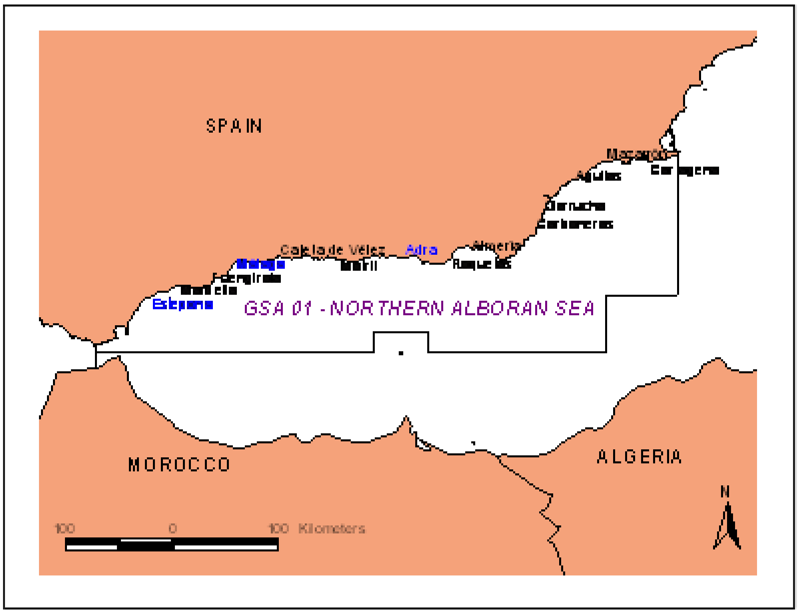


Fig. 5.47.1.1.1. Stock distribution area.

5.47.1.2. Growth

Growth parameters were estimated throughout the DCR biological sampling on a triennial basis (Table 5.47.1.2.1). The method used was the Von Bertalanffy growth equation fit to age (obtained through otoliths reading) and lenght data using non-linear estimation with minimum least squares (Gauss-Newton algorithm) and bootstrapped precision estimates.

Table. 5.47.1.2.1. Growth parameters and Length-Weight relationship.

PERIOD	L8	k	t0	a	b
2002-2004	22.3167	0.40427	-1.58557	0.007412	3.042677
2005-2007	23.0843	0.31274	-2.22053	0.005217	3.177458
2008-2009	22.0	0.45865	-1.41571	0.00595	3.14062

5.47.1.3. Maturity

Maturity at age was estimated throughout the DCR biological sampling from years 2003-2009. These values were considered constant through the years of the assessed time series (2000-2009) (Table 5.47.1.3.1).

Table. 5.47.1.3.1. Maturity ogive.

Age	0	1	2	3	4	5
Prop Matures	0.34	0.90	0.99	1.0	1.0	1.0

5.47.2. Fisheries

5.47.2.1. General description of the fisheries

The current fleet in GSA 01 the Northern Alborán Sea is composed by 131 units, characterised by small vessels. Around 21% of them are smaller than 12 m and 79% are between 12 and 24 m. The purse seine fleet has been continuously decreasing in the last two decades, from more than 230 vessels in 1980 to 131 in 2009 (Figure 5.47.2.1.1). Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the main target species of the purse seine fleet in Northern Alboran GSA 01, but other species with lower commercial value as horse mackerel (*Trachurus spp.*), mackerel (*Scomber spp.*) and gilt sardine (*Sardinella aurita*) are also caught.

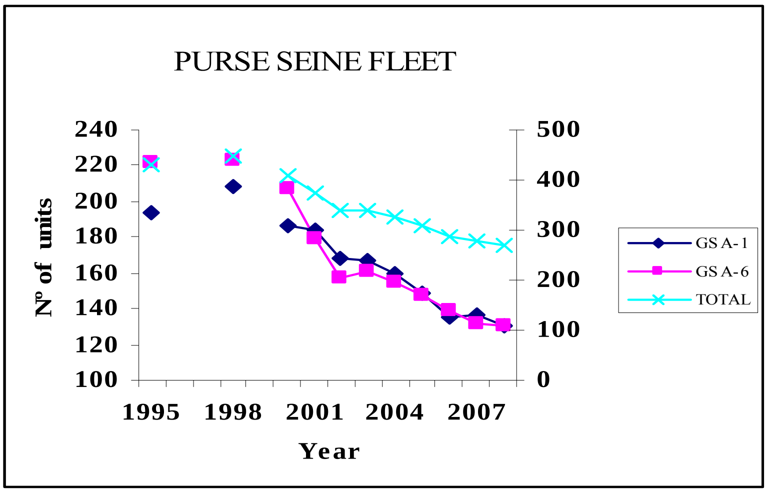


Figure 5.47.2.1.1. Number of units in the purse seine fleet in GSAs 01 and 06.

5.47.2.2. Management regulations applicable in 2009 and 2010

- Fishing license.
- Minimum landing size 11 cm.
- Time at sea 12 hours per day and 5 days a week (no fishing allowed on weekend).
- Several technical measures regulations (gear and mesh size, engine, GRT, etc.).
- Temporary fishing closures (March and April).

5.47.2.3. Catches

5.47.2.3.1. Landings

The annual landings of sardine in the Northern Alborán Sea show annual fluctuations ranged between 3964 and 10002 tons. The data were reported to SGMED-10-02 through the Data Collection Regulation and are listed in Table 5.47.2.3.1.1.

Table 5.47.2.3.1.1. Annual landings (t) by fishing technique (Spanish purse seiners) in GSA 01.

SPECIES	AREA	COUNTRY	FT_LVL4	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
PIL	1	ESP	PS	9325	7457	5348	8244	3964	7208	10002	6766	4423	5926

5.47.2.3.2. Discards

Sardine discards in GSA 01 are negligible.

5.47.2.3.3. Fishing effort

No effort data were reported by Spain to SGMED-10-02 through the DCF data call. Thus, SGMED was unable to conduct an analysis of the effort trend for the major fleets fishing sardine in GSA 01.

5.47.3. Scientific surveys

5.47.3.1.ECOMED and MEDIAS Acoustic Surveys

5.47.3.1.1. Methods

ECOMED and MEDIAS Acoustic Surveys allows for the estimation of abundance index of sardine in GSA 01 (Biomass in metric tons and abundance in number of individuals by species and area).

The ECOMED survey provided data from 1990 to 2008, although the abundance time series used for XSA tuning range from 2003 to 2008 as 1990-2002 acoustic data are currently being re-evaluated. As a result of a gradual increase in the abundance of other species, it has been necessary to revaluate the 1990-2002 acoustic data from ECOMED surveys using different values of the target strength (TS) parameter.

The ECOMED survey covered the entire GSA 01 only in 2004 and 2005, while the survey did cover only the two most important bays in 2003 and 2006. No data for 2007 was available due to bad weather conditions and lack of time.

The ECOMED surveys were carried out on board the R/V Cornide de Saavedra during late autumn (November-December). A multifrequency echosounder is utilised (SIMRAD-ER60) sampling at frequencies of 38 kHz, 70 kHz, 120 kHz and 200 kHz. The ESDU is 1 nm. The pulse duration is 1 msg. The software used for echogram identification was *SonarData Ecoview*.

During ECOMED, the sampling grid is constituted by parallel tracks, perpendicular to the coast. Acoustic sampling is performed during daytime. Experimental fishing with pelagic trawl for schools identification was done at night in the previously tracked positions.

The new MEDIAS acoustic survey was carried out during the summer (June-July) for the first time in 2009. MEDIAS used the same vessel, the same echosounder and the same sampling grid that ECOMED but experimental fishing with pelagic trawl for schools identification was done during the day.

However, MEDIAS sampling coverage was incomplete in 2009 due to logistic problems and no data for GSA 01 was available.

5.47.3.1.2. Geographical distribution patterns

Sardine is distributed in coastal waters all over the North Alborán Sea (GSA 01).

5.47.3.1.3. Trends in abundance and biomass

Both XSA and acoustics methods had the same perception of the state of the stock. The annual landings of sardine in the Northern Alborán Sea show generally strong rise and falls according with recruitment fluctuations. Landings ranged between 4,000 and 10,000 tons with 5,900 t in 2009. This is the most fished species in GSA 01 including both pelagic and demersal species. The economical value of sardine is lower than anchovy but the high catches make it a valuable fishery from a socio-economical perspective.

5.47.3.1.4. Trends in abundance by length or age

Table 5.47.3.1.4.1 lists indices of abundance by length for the years 2003-2008.

Tabl 5.47.3.1.4.1 Indices of abundance by length, 2003-2008.

			Year		
Length	2003	2004	2005	2006	2008
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	280	629	2032	0	0
10.5	280	1914	34	0	0
11	1648	865	6031	0	0
11.5	1368	288	9885	388	0
12	6974	4489	79829	478	0
12.5	5383	7198	139999	843	890140
13	8525	10960	283302	3836	2670421
13.5	18986	10977	333534	5442	2670421
14	39052	50576	408077	6362	8151524
14.5	51346	81447	341463	7123	8661348
15	49601	50190	390003	7099	7541965
15.5	38549	50992	352383	5902	8914238
16	17893	41109	257543	5713	953883
16.5	7082	28308	117270	3392	902975
17	3402	25555	64957	5569	2759834
17.5	2082	35169	29080	7693	1025096
18	1922	49914	2418	8584	56191
18.5	1291	22728	5021	7276	677719
19	1880	14918	10468	3633	2806608
19.5	2292	17275	8352	2641	10348124
20	2264	7983	12338	1458	7663111
20.5	634	4359	7846	272	4412580
21	585	2704	6242	89	3101454
21.5	0	726	2208	0	805713
22	0	262	2496	0	316432
22.5	0	0	288	0	181476
23	0	0	0	0	0
23.5	0	0	0	0	56191
24	0	0	0	0	0

5.47.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.47.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.47.4. Assessment of historic stock parameters

5.47.4.1. Method: VPA-XSA

The assessment of this stock was carried out by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999) using catch data collected by the Spanish National Data Collection. The XSA tuning was performed using abundance index series derived from echo-surveys carried out in the GSA 01.

This is the fourth assessment of *Sardina pilchardus* from GSA 01 using XSA. Previous assessments can be viewed at http://www.gfcm.org.

5.47.4.1.1. Justification

The length of the data series available (10 years, from 2000 to 2009) allowed the use of a VPA tuned with data from surveys and commercial fleet (XSA). The software used was the Lowestoft suite (Darby and Flatman 1994) and FLR 2.2 packages in 2010.

5.47.4.1.2. Input parameters

- Landings time series 2000-2009 from all fishery ports in GSA01.
- Combined ALK (2003-2009) for all the years (DCF official data).
- Length Distributions 2003-2009 (DCF official data), combined for 2000-2002.
- Biological sampling 2003-2009 for Maturity at Age and Weight-Length relationships (DCF official data).
- Tuning data from acoustic surveys ECOMED 2003-2008 (DCF official data).

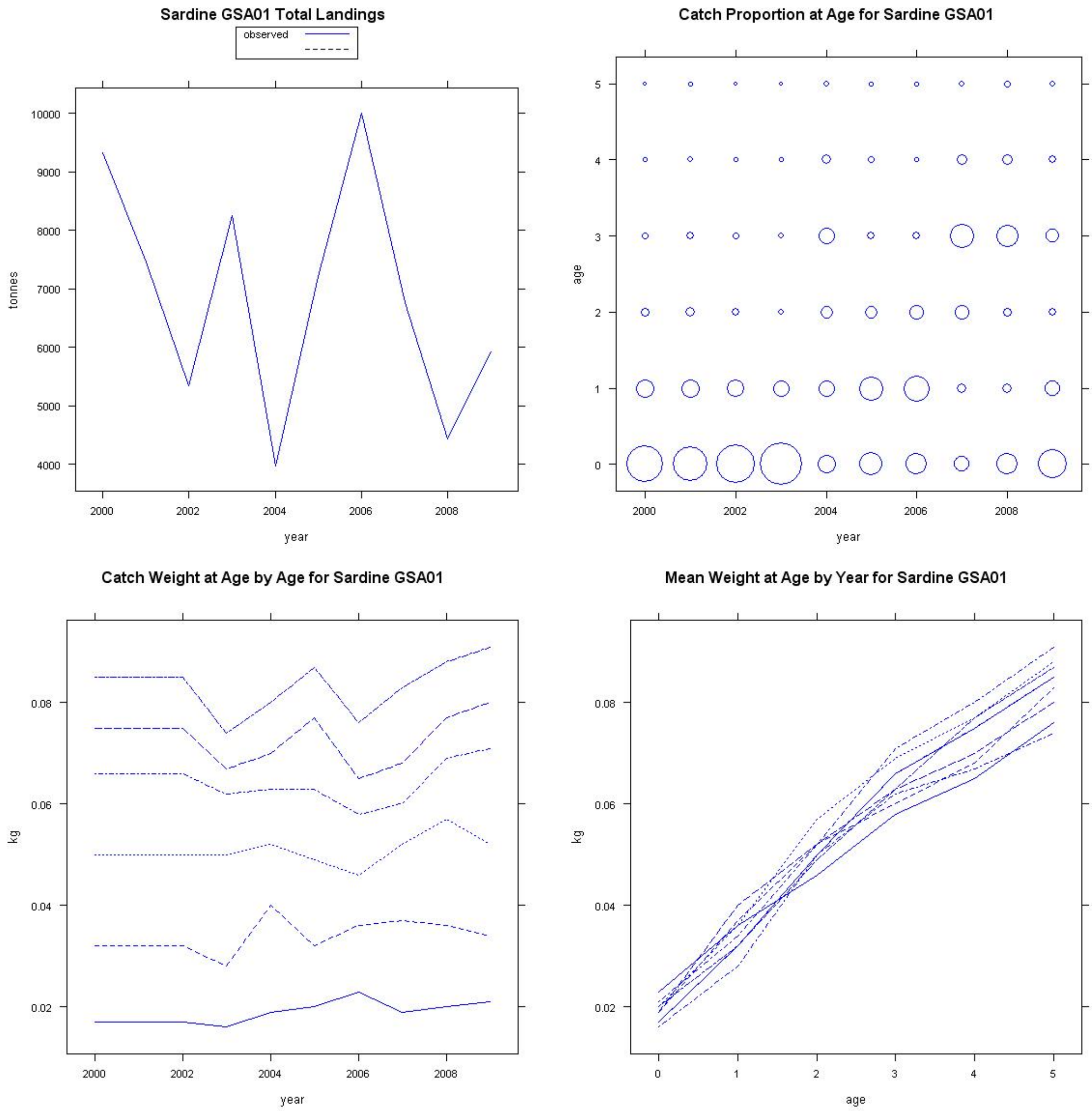


Fig. 5.47.4.1.2.1 Various input parameters to the XSA model.

Tab. 5.47.4.1.2.1 Landings (t) 2000-2009.

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
9325	7457	5348	8244	3964	7208	10002	6766	4423	5926

Tab. 5.47.4.1.2.2 Landings at age (thousands), 2000-2009.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Age 0	202618	141258	127761	250550	22550	73366	87984	26972	26930	63166
Age 1	90143	64800	50449	80714	19613	76927	112297	13569	8842	29731
Age 2	27599	24263	14384	12442	13812	31410	51779	25071	7988	9968
Age 3	16690	16795	9498	15078	19018	14541	18059	49316	28664	25352
Age 4	6784	7012	4028	6070	8744	11182	6133	15806	10039	10063
Age 5	2810	2836	1688	1930	3196	5103	4250	4048	4586	5016

Tab. 5.47.4.1.2.3 Catch weight at age (kg), 2000-2009.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0.017	0.017	0.017	0.016	0.019	0.020	0.023	0.019	0.020	0.021
1	0.032	0.032	0.032	0.028	0.040	0.032	0.036	0.037	0.036	0.034
2	0.050	0.050	0.050	0.050	0.052	0.049	0.046	0.052	0.057	0.052
3	0.066	0.066	0.066	0.062	0.063	0.063	0.058	0.060	0.069	0.071
4	0.075	0.075	0.075	0.067	0.070	0.077	0.065	0.068	0.077	0.080
5	0.085	0.085	0.085	0.074	0.080	0.087	0.076	0.083	0.088	0.091

Table 5.47.4.1.2.4 Tuning data from ECOMED surveys 2003-2008.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	-	-	-	111356	144702	2806356	47276	-	44671	-
1	-	-	-	126889	226070	12962	32466	-	9907	-
2	-	-	-	18057	81859	22838	1981	-	13054	-
3	-	-	-	4802	50659	6179	2011	-	3651	-
4	-	-	-	2073	14107	5412	60	-	2986	-
5	-	-	-	973	4141	2313	0	-	849	-

Input parameters values are in accordance with STECF-SGMED recommendations.

Growth parameters (DCF official data)

PERIOD	L_INF	K	T0
2003-2004	22.3167	0.40427	-1.58557
2005-2007	23.0843	0.31274	-2.22053
2008-2009	22.0	0.45865	-1.41571

Length-weight relationships (DCF official data)

PERIOD	a	b
2003-2004	0.0029	3.3171
2005-2007	0.0040	3.1945
2008-2009	0.0059	3.1406

Maturity at Age (DCF official data)

Age	0	1	2	3	4	5
Prop Matures	0.34	0.90	0.99	1.0	1.0	1.0

A vector of natural mortality rate at age was estimated using the PRODBIOM (Abella et al., 1997):

Age	0	1	2	3	4	5	Mean 0-5	Mean 1-3 (Ages Fbar)
M	1.17	0.44	0.32	0.27	0.25	0.24	0.45	0.34

5.47.4.1.3. Results

The main settings for the XSA are the following:

- Fbar 1-3.
- Age 2 for q stock-size independent.
- Age 3 for q independent of age.
- Fshrinkage = 0.500
- S.E. for fleet terminal estimates ≥ 0.300

XSA Diagnostics are shown in the next figures:

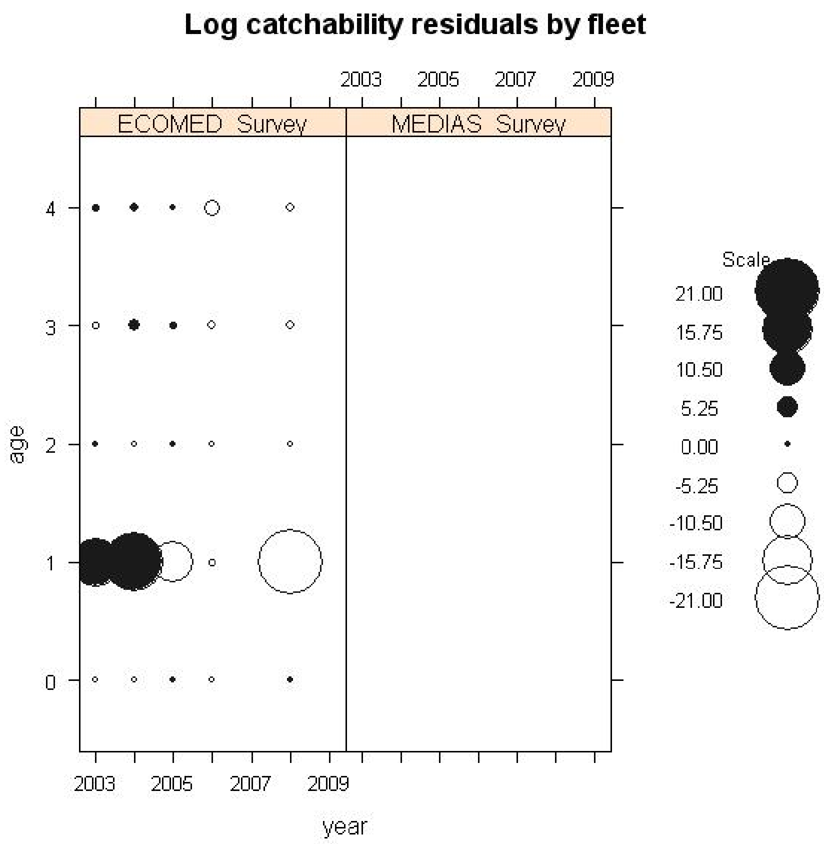


Fig. 5.47.4.1.3.1 Log catchability residuals by fleet.

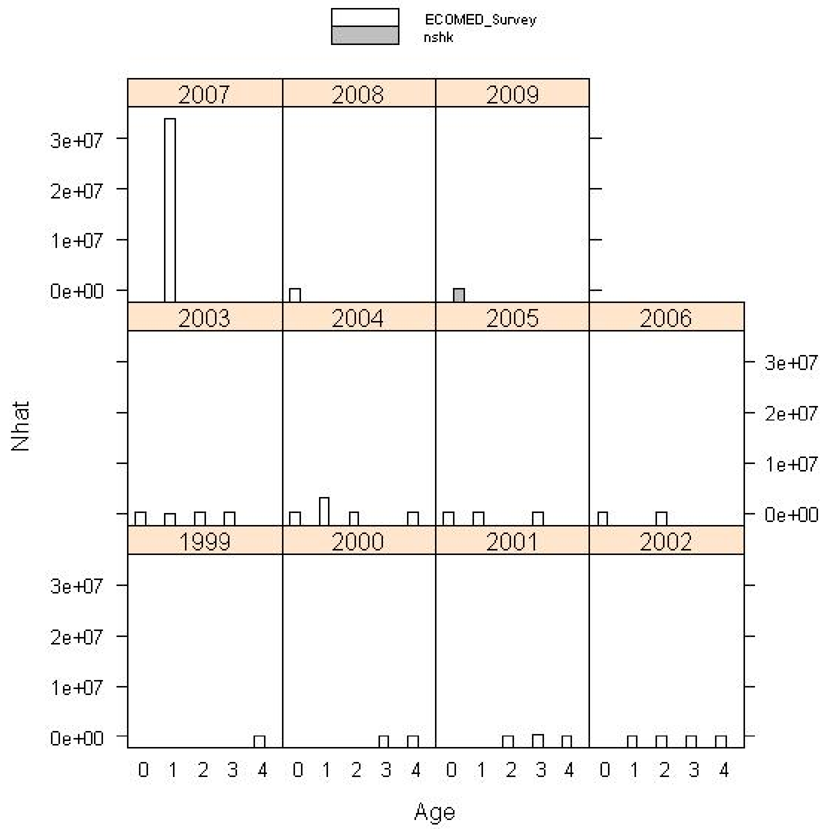


Fig. 5.47.4.1.3.2 Survivors by age.

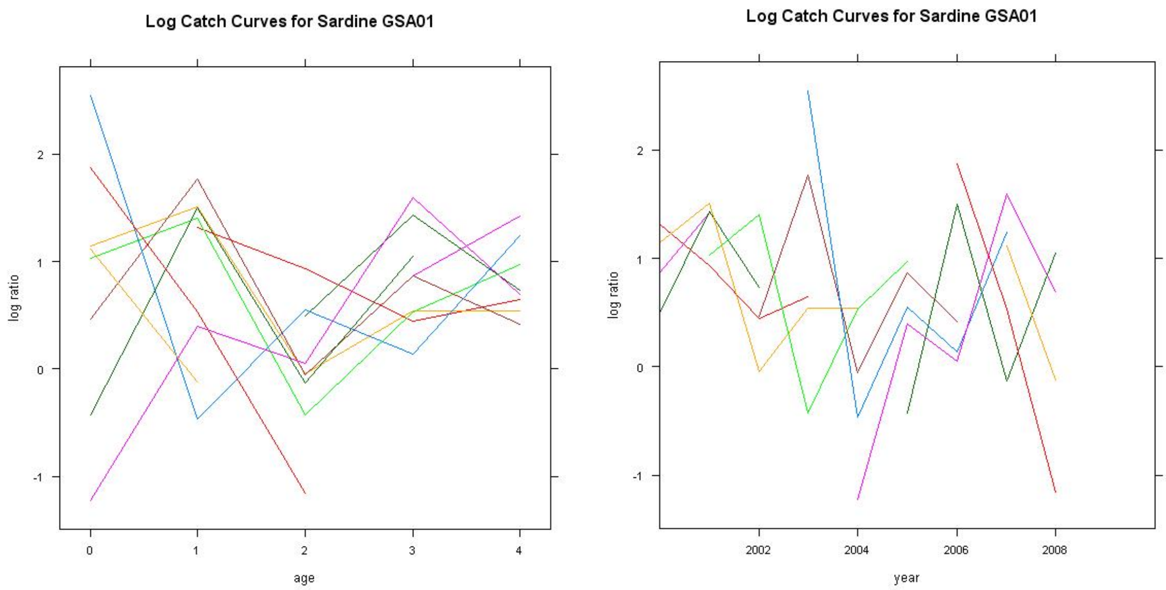


Fig. 5.47.4.1.3.3 Log Catch Curves by age and year.

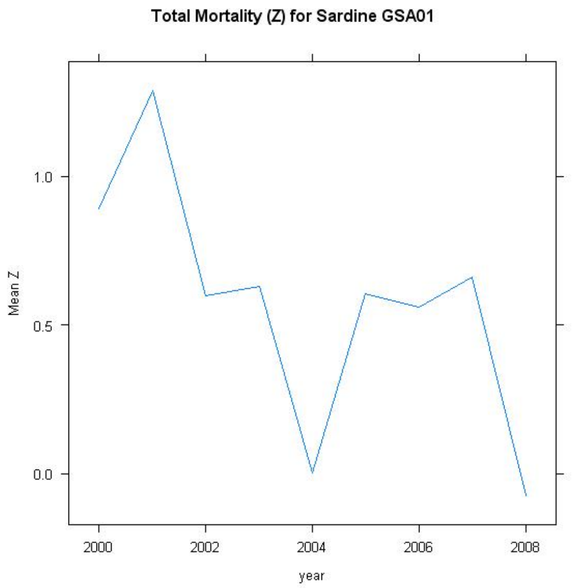


Fig. 5.47.4.1.3.4 Total Mortality (Z) by year and age.

The figures below present the main results from the XSA, the trends in biomass for mature and immature sardines, and the stock-recruitment relationship.

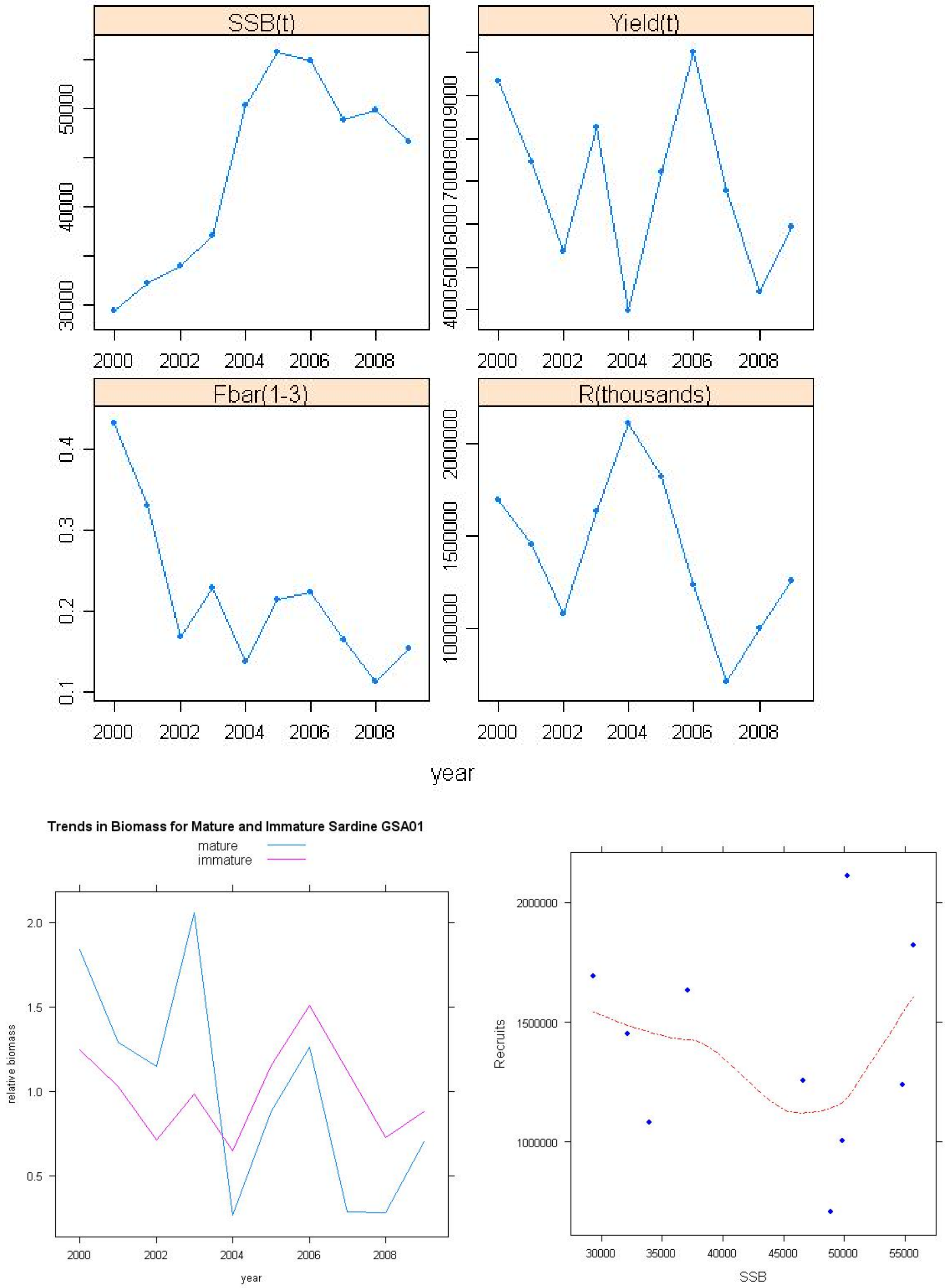


Fig. 5.47.4.1.3.5 Various population parameters obtained by XSA modelling.

Table 5.47.4.1.3.1 Estimated fishing mortality at age, 2000-2009.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0.2417	0.1919	0.2382	0.3218	0.0194	0.075	0.1366	0.0707	0.0494	0.0945
1	0.5468	0.2176	0.1851	0.4781	0.0688	0.1616	0.3103	0.0518	0.0552	0.1335
2	0.36	0.3374	0.0822	0.0761	0.1665	0.1824	0.1895	0.1264	0.0468	0.0983
3	0.3879	0.4372	0.237	0.1286	0.1772	0.296	0.1679	0.3106	0.2319	0.2287
4	0.3878	0.2987	0.187	0.2506	0.1089	0.16	0.2088	0.2326	0.1011	0.1265
5	0.3878	0.2987	0.187	0.2506	0.1089	0.16	0.2088	0.2326	0.1011	0.1265

Table 5.47.4.1.3.2 Estimated stock numbers at age, 2000-2010.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	1693884	1452442	1082002	1634257	2109952	1821883	1237174	709135	1003344	1257591	NA
1	266683	412846	372094	264641	367636	642297	524579	334962	205066	296402	355762
2	107135	99412	213885	199156	105664	221031	351927	247728	204838	124974	167338
3	59412	54278	51513	143055	134015	64958	133736	211428	158523	141936	82426
4	23912	30772	26761	31025	96031	85688	36883	86313	118312	95969	86456
5	9800	12651	17805	17316	18842	67233	57036	23390	53439	83582	66042

Table 5.47.4.1.3.3 XSA summary table of stock parameters without SOP correction, 2000-2009.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SSB	29322	32145	33912	37090	50264	55681	54781	48864	49808	46568
Fbar (1-3)	0.4316	0.3308	0.1681	0.2276	0.1375	0.2134	0.2226	0.1629	0.1113	0.1535
Recruitment	1693884	1452442	1082002	1634257	2109952	1821883	1237174	709135	1003344	1257591

The annual landings of sardine in the Northern Alborán Sea showed historically strong fluctuations. Landings ranged between 4000 and 10000 tons. After the decreasing trend observed since 2006, landings slightly increased in 2009 reaching up 5900 t. Since 2000 fishing mortality (F_{1-3}) has varied between 0.43 and 0.11. The maximum was observed in 2000, then falling down to the minimum in 2008. F_{1-3} remains at low levels in 2009 (0.15). After the maximum observed in 2004 (2110 millions), recruitment followed a decreasing trend reaching their minimum in 2007 (709 millions). In 2009, the recruitment (1258 millions) continues the recovery trend observed in 2008. SGMED highlighted that the fishery is highly dependent of the recruitment strength. Since 2000, when the minimum was observed (29300 t), SSB showed an increasing trend reaching its maximum in 2005 (55700 t). From 2005 to 2009 a slight decrease is observed with around 46600 t in 2009.

Retrospective analysis was applied in the XSA model for the sardine in GSA 01 with seven year backward analysis. Results are presented in Fig. 5.47.4.1.3.6 showing an underestimation of recruitment and spawning biomass and an overestimation of fishing mortality.

The annual exploitation rate E = F/(F+M) or F/Z was calculated and plotted over the years. The constant M value (0.34) was estimated as the mean of the 1-3 ages of the M vector. The values obtained were compared with the threshold F/Z = 0.4 adopted as biological reference point for small pelagics (Patterson, 1992) by SGMED. The trends in values of F/Z were plotted in Fig. 5.47.4.1.3.7.

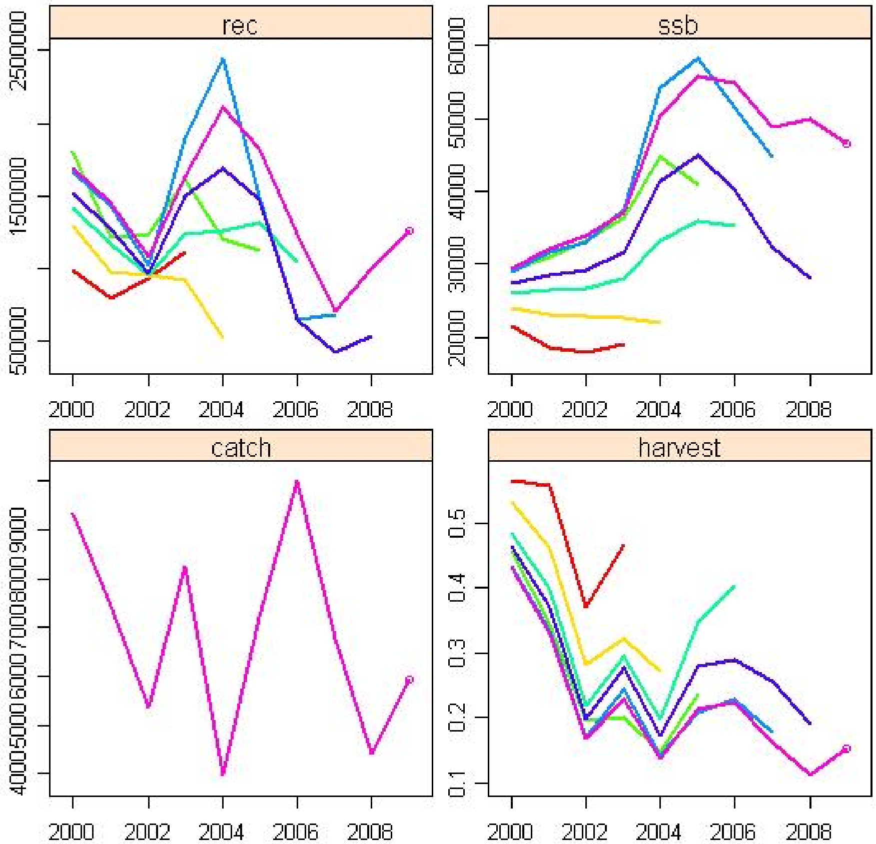


Fig. 5.47.4.1.3.6 Retrospective patterns in the XSA assessment.

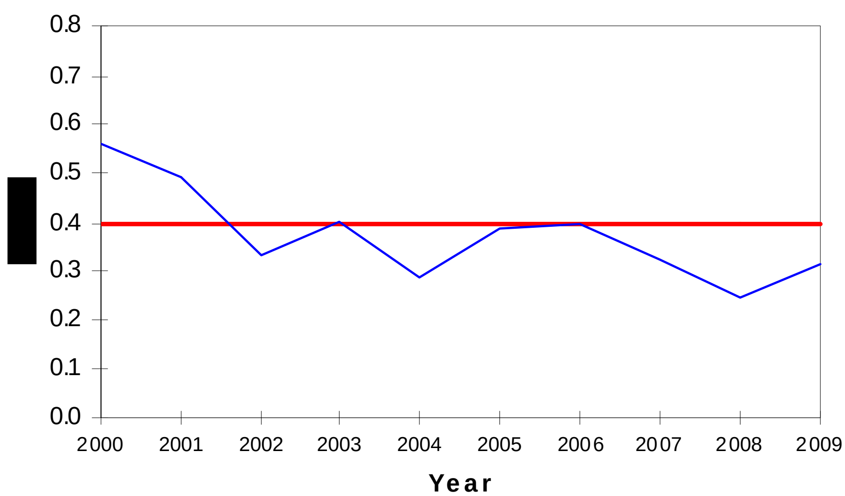


Fig. 5.47.4.1.3.7 Trend in exploitation rate in comparison with E=0.4 level.

5.47.5. Long term prediction

5.47.5.1. Justification

Yield per recruit analysis was conducted in the SGMED-10-02 assuming equilibrium conditions.

5.47.5.2. Input parameters

Yield per recruit analyses was conducted based on the exploitation pattern resulting from the XSA model and population parameters. Minimum and maximum ages for the analysis were considered to be age group 0 and 5. Stock weight at age, catch weight at age and maturity ogive was estimated as mean values between 2000 and 2009. Natural mortality vector values were applied per age group using ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED-09-01. Fishing mortalities were the exploitation pattern F in 2009. Reference F was considered to be mean F for ages 1 to 3. Input parameters are shown in Table 5.47.5.2.1.

Table 5.47.5.2.1 YpR input parameters.

age group	stock weight	catch weight	maturity	F	M
0	0.019	0.019	0.34	0.0945	1.17
1	0.034	0.034	0.90	0.1335	0.44
2	0.051	0.051	0.99	0.0983	0.32
3	0.064	0.064	1	0.2287	0.27
4	0.073	0.073	1	0.1265	0.25
5	0.083	0.083	1	0.1265	0.24

5.47.5.3. Results

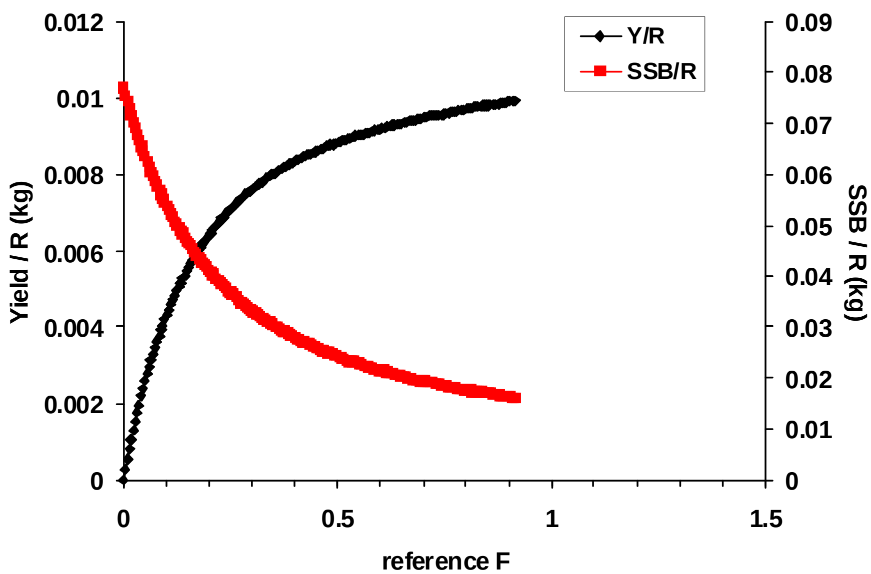


Fig. 5.47.5.3.1 YpR and SSBpR with increasing fishing mortality.

Tab. 5.47.5.3.1 Resulting management reference values

$F_{0.1}$	0.3868
F_{max}	0.9164
F_{ref}	0.1535

Y/R analyses (Fig. 5.47.5.3.1) were not considered reliable due to its flat-topped shape. Therefore, $F_{0.1}$ cannot be used as a reference point for this stock. Also, the use of yield-per-recruit analysis for estimating targets for long-term management of pelagic fisheries has been discouraged (Patterson, 1992).

5.47.6. Data quality and availability

No effort data were reported by Spain to SGMED-10-02 through the DCF data call. Thus, SGMED were unable to conduct an analysis of the effort trend for the major fleets fishing sardine in GSA 01. The ECOMED survey covered the entire GSA 01 only in 2004 and 2005, while the survey did cover only the two most important bays in 2003 and 2006. No data for 2007 was available due to bad weather conditions and lack of time. MEDIAS sampling coverage was incomplete in 2009 due to logistic problems and no data for GSA 01 was available. Inconsistency and data incompleteness in the tuning fleet might affect the assessment results as this is the only tuning fleet available for this assessment.

5.47.7. Scientific advice

5.47.7.1. Short term considerations

5.47.7.1.1. State of the spawning stock size

Results of the Extended Survivor Analysis (XSA) analysis indicated a slight decrease from the highest levels observed in 2005. However the sardine SSB remains at medium-high levels also in 2009.

The state of the spawning biomass in relation to precautionary limits cannot be evaluated since there are no precautionary reference points proposed or agreed due to the short series of data available. It should be considered that this assessment is based on a short time series of data and not suitable to suggest reference points of B_{lim}. Moreover, sardine is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends on environmental conditions.

No precautionary reference points were proposed for biomass levels, and hence SGMED-10-02 cannot comment on the state of the stock with this respect.

5.47.7.1.2. State of recruitment

XSA model estimates had shown an increase in the number of recruits in the last two years (2008-2009). In 2009 recruitment was well above the minimum recruitment level observed in 2007.

The trend of the recruitments is important as small pelagic stocks and fisheries are highly dependent of the recruitment strength.

5.47.7.1.3. State of exploitation

Based on XSA results, the mean F (for ages 1 to 3) followed a decreasing trend along the time series (2000-2009) and remains at low levels in 2009.

The exploitation rate during the last eight years is below the exploitation reference points (E=0.4) proposed by Patterson (1992) and suggested by SGMED as an appropriate limit management reference point consistent with high long term yields for small pelagics.

Based on this assessment results the stock is considered sustainably exploited. However, SGMED stresses that the use of the exploitation rate is very sensitive to M values.

The management of the sardine fisheries in GSA 01 needs to account for multi-species effects, mainly the interaction with anchovy.

Some work was done and some preliminary reference points were estimated in SGMED-10-02 based on exploitation rate and Yield-per-Recruit analysis ($F_{0.1}$ & F_{max}). However, the use of the exploitation rate is very sensitive to M values and the use of yield-per-recruit targets for long-term management of pelagic fisheries has been specifically discouraged (Patterson, 1992). Thus, in light of the above considerations, SGMED suggest that E=0.4 is suitable reference point for this stock, also in accordance on what agreed at previous SGMED meetings.

5.48. Stock assessment of sardine in GSA 06

5.48.1. Stock identification and biological features

5.48.1.1. Stock Identification

The assessment of small pelagic stock in the Mediterranean is conducted by Geografical Sub-Areas (GSAs) as defined in the GFCM framework. Little or no specific work has been carried out on the stock identification of small pelagic species in the Mediterranean and further analysis is needed to evaluate the small pelagic fish stock complex in the area. Fig. 5.48.1.1.1 shows the GFCM Geographical Sub- Area GSA 06, indicating all landings ports. Sampled ports are highlighted in blue.

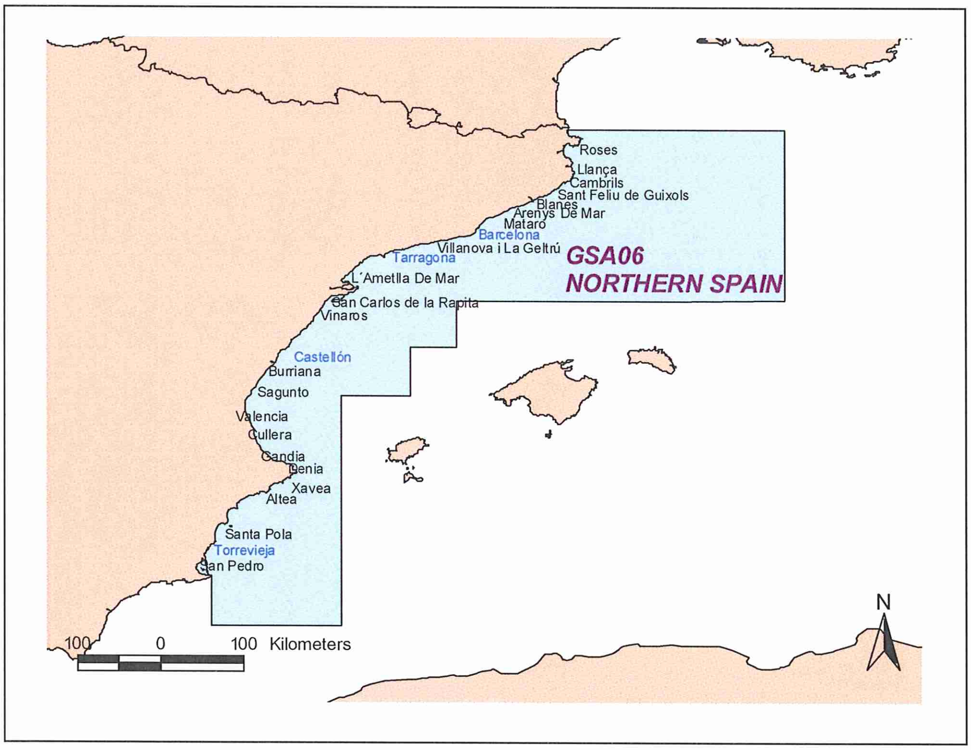


Fig. 5.48.1.1.1 Stock distribuition area.

5.48.1.2. Growth

Growth parameters were estimated throughout the DCR biological sampling on a triennial basis (Tab. 5.48.1.2.1). The growth parameters were derived from anchovy in GSA 01. The used method was the Von Bertalanffy growth equation fit using age (obtained through otolith readings) and length data using non-linear estimation with minimum least squares (Gauss-Newton algorithm) and Bootstrapped precision estimates.

Table 5.48.1.2.1 Growth parameters.

PERIOD	L8	k	t0	a	b
2002-2004	22.38	0.2819	-2.4849	0.00337	3.305131
2005-2008	22.95	0.2506	-2.9262	0.00525	3.140001
2008-2009	22.00	0.4586	-1.4157	0.00595	3.140623

5.48.1.3. Maturity

Maturity at age was estimated throughout the DCR biological sampling from years 2004-2009. These values were considered constant through the years of the assessed time series (1994-2009) (Table 5.48.1.3.1).

Tab. 5.48.1.3.1 Maturity ogive.

Age	0	1	2	3	4	5+
Prop. Matures	0.38	0.85	0.99	1.00	1.00	1.00

5.48.2. Fisheries

5.48.2.1. General description of the fisheries

The most updated fleet information corresponds to GFCM WG 2009, containing data up to 2008. The purse seine fleet operating in GSA 06 is composed by 130 units: 4% are smaller than 12 m in length, 87% between 12 and 24 m and 9% larger than 24 m. The fleet continuously decreased in the last decade, from more than 222 vessels in 1995 to 130 in 2008. This strong reduction (59%) is possibly linked to a continuous decline of small pelagic catches.

Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are the main target species of the purse seine fleet in GSA 06, but other species with lower economical importance are also captured, sometimes representing a high percentage of the capture as horse mackerel (*Trachurus* spp.), mackerel (*Scomber* spp.) and gilt sardine (*Sardinella aurita*).

5.48.2.2. Management regulations applicable in 2009 and 2010

- Fishing license.
- Minimum landing size 11 cm.
- No fishing allowed on weekend. Time at sea 12 hours per day and 5 days a week: fully observed
- Several technical measures regulations (gear and mesh size, engine, GRT, etc.).
- Temporary fishing closures (From 1st December to 31st January).

5.48.2.3. Catches

5.48.2.3.1. Landings

The annual landings of sardine (*Sardina pilchardus*) in GSA 06 for the whole time series ranged between 52,440 and 7,900 t. Landings in 2009 were 7,900 t (Table 5.48.2.3.1.1). This is the lowest values of the assessed time series, half of what reported in 2008 (14,120 t) which is the second lowest value of the time series. The highest value of the time series corresponds to the first year analysed (1994 with 52,440 t). Hence, the time series shows a continuous and very sharp decrease from the beginning of the times series.

Tab. 5.48.2.3.1.1 Annual sardine landings (t) by fishing technique (purse seiners) in GSA 06.

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002
Catch (t)	52439	48525	44387	35618	32274	36142	36972	30275	18762

Year	2003	2004	2005	2006	2007	2008	2009
Catch (t)	20817	24874	22081	29381	23984	14123	7896

5.48.2.3.2. Discards

Discards of anchovy in GSA 06 are considered negliglible. Only in 2004 380 t were reported to SGMED-10-02 through the DCF official data call.

5.48.2.3.3. Fishing effort

No effort data were reported by Spain to SGMED-10-02 through the DCF official data call. Thus, SGMED was unable to conduct an analysis of the effort trend for the major fleets fishing sardine in GSA 06.

5.48.3. Scientific surveys

5.48.3.1. Method 1: ECOMED acoustic survey

ECOMED was carried out data from 1990 -2008, although the abundance time series used for XSA tuning is from 2003-2008. ECOMED is carried out in winter season, targeting mainly the spawning period of sardine. MEDIAS, a new pan-mediterranean acoustic survey started in 2009 and it is carried out during the summer, targeting mainly the spawning period of anchovy.

5.48.3.1.1. Methods

The sampling coverage is complete for all analysed years in GSA 06 for both acoustic surveys.

ECOMED Surveys were carried out on board the R/V Cornide de Saavedra during late autumn (November-December). MEDIAS surveys were carried out on board the R/V Cornide de Saavedra during early summer (June-July). A multifrequency echosounder was utilised (SIMRAD-ER60), sampling at frequencies of 38 kHz, 70 kHz, 120 kHz and 200 kHz. The ESDU is 1 nm. The pulse duration is 1 msg. The software used for echogram identification is *SonarData Ecoview*.

During ECOMED, the sampling grid is constituted by parallel tracks, perpendicular to the coast. Acoustic sampling is performed during daytime. Experimental fishing with pelagic trawl for schools identification was done at night in the previously tracked positions.

MEDIAS used the same vessel, the same echosounder and the same sampling grid that ECOMED but experimental fishing with pelagic trawl for schools identification was done during the day.

5.48.3.1.2. Geographical distribution patterns

The studied area is usually splitted in two regions, the Tramontana Region (from Cape Creus to Cape La Nao) and Levantine Region (from Cape La Nao to Cape Palos). The ECOMED time period (November – December) when the ECOMED survey is conducted corresponds to the recruitment season of the anchovy and spawning season of sardine. Hence the acoustic survey provides an estimation of the recruitment of the anchovy. They are two recruitment areas: one located between Barcelona and the south of the Ebro River Delta (the most important) and other in Rosas Bay.

5.48.3.1.3. Trends in abundance and biomass

Table 5.48.3.1.3.1 Survey estimates of abundance an biomass.

SPECIES	**SURVEY**	**YEAR**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
PIL	ECOMED	Number (mill)	4375	2699	4882	2079	750	534
		Biomass (t)	71865	48174	103240	49796	15298	9375

SPECIES	**SURVEY**	**YEAR**	**2009**
PIL	MEDIAS	Number (mill)	3696
		Biomass (t)	26640

According to survey estimates, 2005 showed the largest abundance of anchovy. The lowest value was observed in 2008. It should have to note that data from 2008 and 2009 and not directly comparable as they come from different acoustic surveys in different seasons and also different methodology of fishing (ECOMED at night and MEDIAS at daytime).

5.48.3.1.4. *Trends in abundance by length or age*

Tab. 5.48.3.1.4.1 Survey abundance at length, 2003-2008.

ECOMED			SPECIES	PIL			
		YEAR					
	LENGTH_CLASS	2003	2004	2005	2006	2007	2008
	3.5						
	4						
	4.5						
	5						
	5.5						
	6						
	6.5						
	7						
	7.5	0	2451	0	0	0	0
	8	10282	8243	0	5762	0	10282
	8.5	43152	13642	1033	13405	0	43152
	9	103696	18250	9417	25700	0	103696
	9.5	114488	43401	23969	39530	0	114488
	10	260915	114529	53875	75082	0	260915
	10.5	425964	202785	97138	117856	1279	425964
	11	450584	262844	153859	167935	35258	450584
	11.5	422296	348402	192041	116000	57566	422296
	12	405254	306660	386029	129273	98169	405254
	12.5	314443	231811	372013	112374	92233	314443
	13	228979	148160	503970	94129	103666	228979
	13.5	222564	105186	467772	79581	67951	222564
	14	220427	157973	534679	66583	29891	220427
	14.5	208072	163656	426010	59754	23603	208072
	15	188011	125127	467218	70424	35636	188011
	15.5	140243	109292	417202	96267	29645	140243
	16	119328	70407	325049	106907	33792	119328
	16.5	120379	47494	158994	103976	28715	120379
	17	105765	36239	109362	131944	28375	105765
	17.5	73208	44154	69308	117168	27294	73208
	18	65483	53923	27201	123631	21649	65483
	18.5	49412	26849	17055	90162	16311	49412
	19	31131	17055	17156	68544	10877	31131
	19.5	27774	20392	14110	32853	4392	27774
	20	14517	9730	14142	15835	3120	14517
	20.5	5952	5490	8924	7673	303	5952
	21	2306	3147	6874	4920	616	2306
	21.5	0	1087	2927	2658	120	0
	22	765	303	3351	2450	0	765
	22.5	0	27	1003	393	0	0
	23	0	0	0	393	0	0
	23.5						
	24						

Tab. 5.48.3.1.4.2 Survey abundance at length, 2009.

MEDIAS	SPECIES	PIL
		YEAR
	LENGTH_CLASS	2009
	3.5	
	4	
	4.5	
	5	
	5.5	
	6	3114
	6.5	4566
	7	7835
	7.5	21826
	8	132062
	8.5	473956
	9	592134
	9.5	790704
	10	650040
	10.5	443750
	11	304518
	11.5	136442
	12	41486
	12.5	19144
	13	4401
	13.5	9606
	14	14829
	14.5	11219
	15	11735
	15.5	7665
	16	6743
	16.5	3626
	17	2180
	17.5	1836
	18	389
	18.5	275
	19	200
	19.5	38
	20	0
	20.5	38
	21	
	21.5	
	22	
	22.5	
	23	
	23.5	
	24	

5.48.3.1.5. Trends in growth

No analyses conducted.

5.48.3.1.6. Trends in maturity

No analyses conducted.

5.48.4. Assessment of historic stock parameters

5.48.4.1. Method 1: XSA

5.48.4.1.1. Justification

This assessment is based on VPA (XSA) methods, tuned by acoustic surveys (see previous section).

5.48.4.1.2. Input parameters

Fishery assessment by VPA methods of the Spanish sardine stock GSA 06 is shown. This assessment is produced with the package FLR.

Data used for XSA:

- Landings from 1994 to 2009.
- ALK 2004-2009 (DCF official data), combined ALK for 1994-2003. Length Distributions 1994-2009.
- Biological sampling 2004-2009 for Maturity at age and Weight-Length relationships (DCF official data).
- Tuning data from acoustic surveys ECOMED and MEDIAS (DCF official data).

Input data for the assessment model are the following.

Table 5.48.4.1.2.1 Landings (t) 2002-2009.

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002
Catch (t)	52439	48525	44387	35618	32274	36142	36972	30275	18762

Year	2003	2004	2005	2006	2007	2008	2009
Catch (t)	20817	24874	22081	29381	23984	14123	7896

Table 5.48.4.1.2.2 Catch numbers at age 2003-2009 (thousands).

Catch in numbers (thousands)					
1	2				
1994	2009				
0	5				
1					
494569	941781	300744	54740	6867	1375
594098	919897	245670	32726	2983	450
866001	831054	160898	29361	3459	516
425922	653478	178067	27301	2623	275
355520	585036	164908	26023	3219	387
193194	598499	226686	36172	3433	319
341089	633136	207861	38368	5734	672
197682	477321	193795	38383	6247	946
187372	340132	103026	15893	1408	123
232292	345204	111670	19612	3263	515
179311	565322	105701	24194	8596	3198
240491	394545	156411	36016	6123	1444
95769	418667	263762	68543	11390	1000
189211	347590	171745	54387	16573	2450
64546	142840	107209	49323	15991	2490
148125	123068	30975	3721	719	3355

Table 5.48.4.1.2.3 Catch and stock weight at age (kg), 2003-2009.

Mean Weight in Catch (kilograms)					
1	3				
1994	2009				
0	5				
1					
0.023	0.03	0.039	0.048	0.062	0.072
0.023	0.028	0.036	0.045	0.056	0.072
0.02	0.026	0.034	0.045	0.06	0.071
0.022	0.028	0.038	0.047	0.059	0.061
0.023	0.029	0.037	0.047	0.059	0.062
0.027	0.031	0.037	0.046	0.059	0.062
0.023	0.03	0.039	0.048	0.059	0.062
0.025	0.032	0.039	0.049	0.061	0.066
0.023	0.03	0.038	0.046	0.057	0.059
0.021	0.03	0.038	0.05	0.063	0.069
0.02	0.028	0.036	0.046	0.06	0.069
0.017	0.026	0.036	0.047	0.059	0.077
0.021	0.031	0.038	0.047	0.058	0.075
0.02	0.029	0.039	0.051	0.056	0.064
0.019	0.031	0.043	0.052	0.057	0.064

Table 5.48.4.1.2.4 Tuning data from ECOMED surveys 2003-2008 and MEDIAS in 2009.

Sardine GSA06 - survey (thousands) and fleet (thousands and days by 100HP)						
102						
FLT01-ECOMED (thousands)						
2003	2009					
1	1	0.88	0.93			
0	5					
1	2644895	1023948	296513	110333	38387	8566
1	1452813	663482	43619	7767	6443	3046
1	1822703	138617	33541	2261	2198	2063
1	1875572	974658	200506	71175	29054	23748
1	464073	142192	56599	13104	6209	1600
1	243165	80859	27476	6329	1790	654
0	0	0	0	0	0	0
FLT02-MEDIAS (thousands)						
2003	2009					
1	1	0.45	0.53			
0	5					
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1	2997562	50608	9719	936	158	11

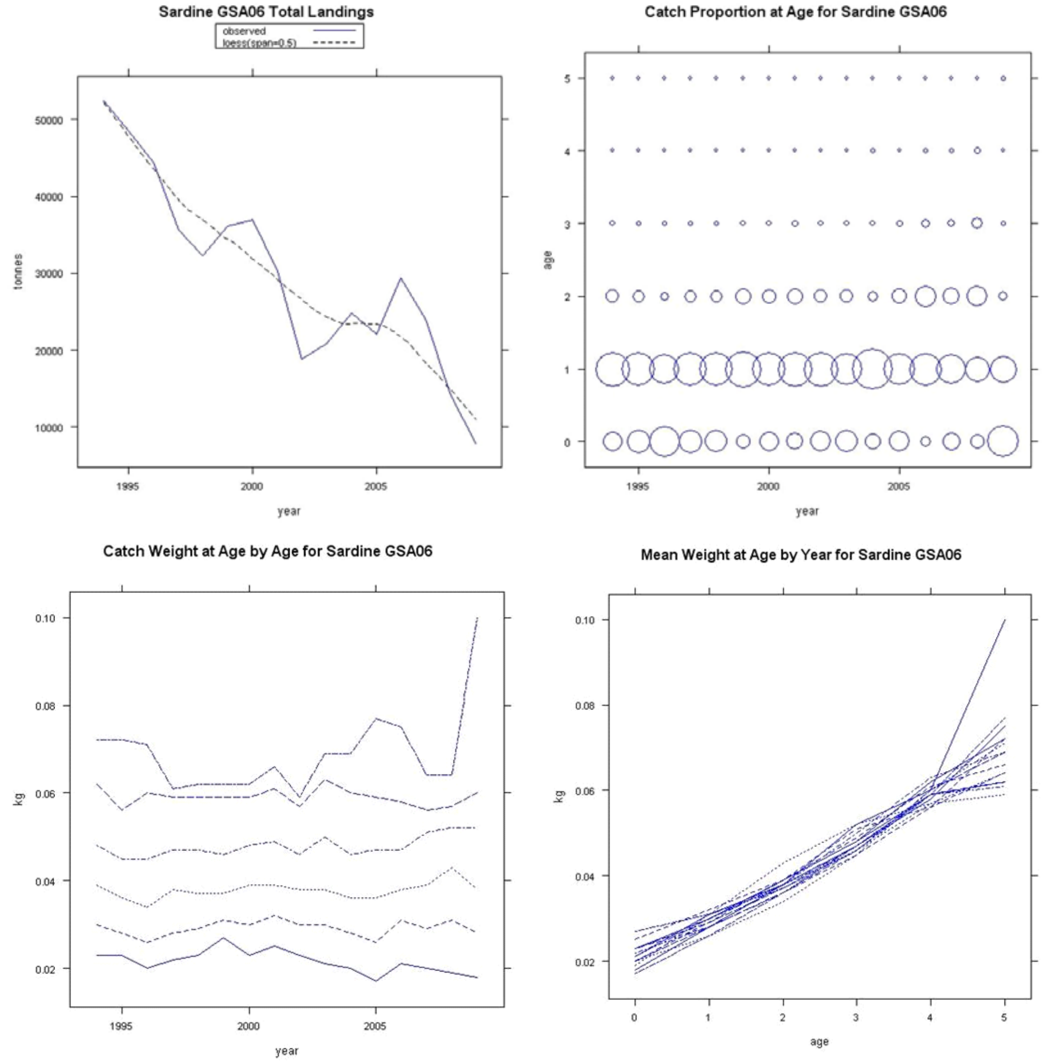


Fig. 5.48.4.1.2.1 Trends in input parameters.

Table 5.48.4.1.2.5 Input parameters.

Input Parameters GSA06

- **Growth Parameters:**

  Linf = 22　　k = 0.4586　　t_0 = -1.41

- **Length-weight relationship:**

  a = 0.006　　b = 3.14

- **Natural Mortality Vector PRODBIOM (Abella *et al.*1997):**

Age	0	1	2	3	4	5	Prom	Prom(1-3)
M	1.20	0.46	0.34	0.29	0.26	0.25	0.47	0.36

- **Maturity at Age**

Age	0	1	2	3	4	5
PropMat	0.38	0.85	0.99	1.00	1.00	1.00

5.48.4.1.3. Results including sensitivity analyses

An exploratory analysis was conducted estimating a Log Catch Curves analysis (Fig. 5.48.4.1.3.1). Log Catch Curves show no conflicts between ages and cohorts follow the standard pattern level of an exploited cohort when entering and passing through the fishery.

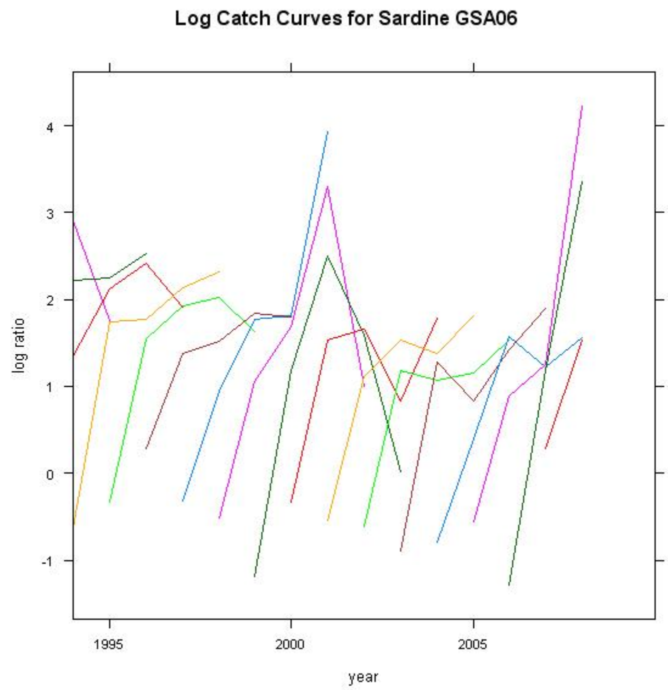


Fig. 5.48.4.1.3.1 Log-transformed catch curves.

The main settings for the XSA are the following:

- Fbar Ages: 1-3
- Age 2 for q stock-size independent
- Age 3 for q independent of age
- Fshrinkage = 0.5 and S.E. for fleet terminal estimates ≥ 0.300

XSA Diagnostics in the form of residuals by fleet are shown in Fig. 5.48.4.1.3.2 and did not show any particular trend. Medias cannot contribute to tune the model as the time series needs more than one year.

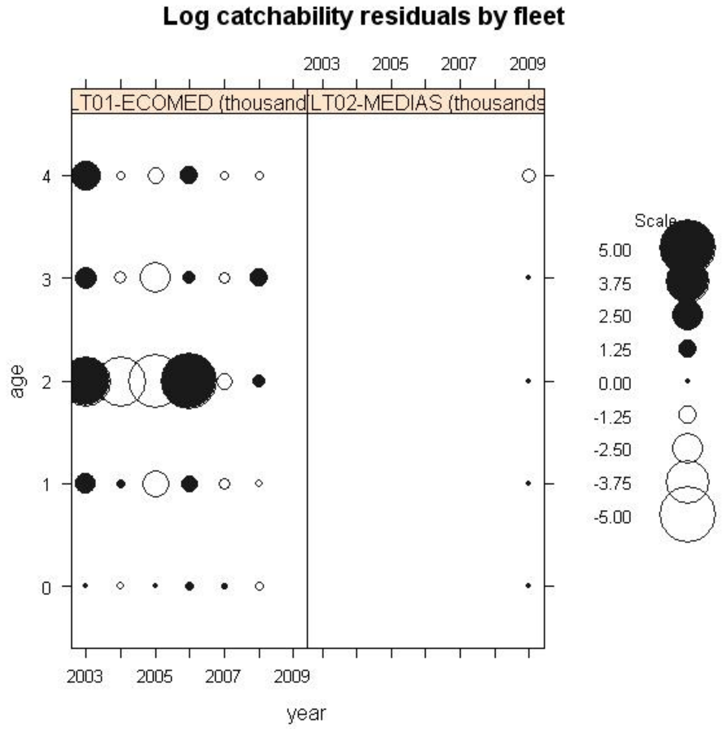


Fig. 5.48.4.1.3.2 XSA Diagnostics: Log-transformed catchability residuals.

Tab. 5.48.4.1.3.1 Estimated fishing mortalities at age, 1994-2009.

Fishing mortality (F) at age						
YEAR	1994	1995	1996	1997	1998	1999
AGE						
0	0.1616	0.2009	0.3213	0.1667	0.1449	0.0829
1	1.1491	1.3784	1.2504	1.066	0.8473	0.9212
2	1.8896	1.8246	1.4899	1.5919	1.2613	1.4726
3	2.4197	1.8171	1.9083	1.6045	1.5305	1.429
4	1.4292	1.3273	1.2631	1.1249	0.9601	0.9911
+gp	1.4292	1.3273	1.2631	1.1249	0.9601	0.9911

Fishing mortality (F) at age						
YEAR	2000	2001	2002	2003	2004	2005
AGE						
0	0.1877	0.1358	0.1215	0.0956	0.0791	0.1263
1	1.0485	1.0867	0.8531	0.7891	0.8209	0.5372
2	1.5302	1.8725	1.0012	1.078	0.7959	0.7449
3	1.5115	2.4742	0.9638	0.5961	0.8569	0.8393
4	1.0862	1.4163	0.7446	0.5768	0.6355	0.6011
+gp	1.0862	1.4163	0.7446	0.5768	0.6355	0.6011
FBAR 1-3	1.3634	1.8111	0.9394	0.8211	0.8246	0.7071

Fishing mortality (F) at age						
YEAR	2006	2007	2008	2009		
AGE						
0	0.0776	0.3393	0.1074	0.1249		
1	0.7712	1.1146	1.2018	0.6848		
2	1.2355	1.2423	2.8569	1.3964		
3	1.0913	1.1693	3.491	1.5157		
4	0.7928	0.9935	1.9611	0.9433		
+gp	0.7928	0.9935	1.9611	0.9433		
FBAR 1-3	1.0327	1.1754	2.5166	1.1990		

Tab. 5.48.4.1.3.2 Estimated stock numbers at age (thousands), 1994-2010.

Stock number at age (start of year)			Numbers*10**-3		
YEAR	1994	1995	1996	1997	1998	1999
AGE						
0	6040022	6E+06	6E+06	5054404	4802555	4425282
1	1735295	2E+06	1E+06	1254480	1288606	1251388
2	419939	347187	246208	265003	272723	348645
3	69460	45173	39854	39500	38392	54989
4	10283	4623	5492	4423	5940	6217
+gp	1986	674	793	450	695	562
0 TOTAL	8276985	8E+06	8E+06	6618261	6408911	6087083
Stock number at age (start of year)			Numbers*10**-3			
YEAR	2000	2001	2002	2003	2004	2005
AGE						
0	3631401	3E+06	3E+06	4642090	4293528	3692886
1	1226842	906563	745916	796078	1270686	1194778
2	314453	271438	193051	200638	228275	352996
3	56908	48454	29703	50489	48596	73303
4	9857	9393	3054	8478	20814	15434
+gp	1121	1372	261	1312	7585	3568
0 TOTAL	5240583	4E+06	4E+06	5699085	5869484	5332965
Stock number at age (start of year)			Numbers*10**-3			
YEAR	2006	2007	2008	2009	2010	
AGE						
0	2336038	1E+06	1E+06	2299125	0	
1	980292	651042	257065	312395	611190	
2	440765	286197	134820	48790	99428	
3	119294	91196	58811	5512	8595	
4	23695	29972	21193	1341	906	
+gp	2031	4309	3153	6091	2249	
0 TOTAL	3902114	2E+06	2E+06	2673254	722368	

Tab. 5.48.4.1.3.3 XSA stock summary table of estimated stock parameters without SoP correction, 1994-2009.

Summary (without SOP correction) Terminal Fs derived using XSA (With F shrinkage)						
	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 1-3
	Age 0					
1994	6040022	211472	117368	52439	0.4468	1.8195
1995	5948975	195004	103545	48525	0.4686	1.6734
1996	5742979	163519	86506	44387	0.5131	1.5495
1997	5054404	158537	84226	35618	0.4229	1.4208
1998	4802555	160117	85926	32274	0.3756	1.2130
1999	4425282	174107	94079	36142	0.3842	1.2743
2000	3631401	135974	78547	36972	0.4707	1.3634
2001	2836727	113552	65125	30275	0.4649	1.8111
2002	2984487	99912	53924	18762	0.3479	0.9394
2003	4642090	132140	68041	20817	0.3059	0.8211
2004	4293528	133675	75016	24874	0.3316	0.8246
2005	3692886	111182	67472	22081	0.3273	0.7071
2006	2336038	103328	68187	29381	0.4309	1.0327
2007	1198252	60612	42810	23984	0.5602	1.1754
2008	1154797	40175	25319	14123	0.5578	2.5166
2009	2299125	52962	25973	7896	0.304	1.1990
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Figure 5.48.4.1.3.3 show the summary results from the XSA, i.e. Total Landings, Fishing Mortality (F_{bar} 1-3) by year, Recruitment in number and Spawning Stock Biomass (SSB).

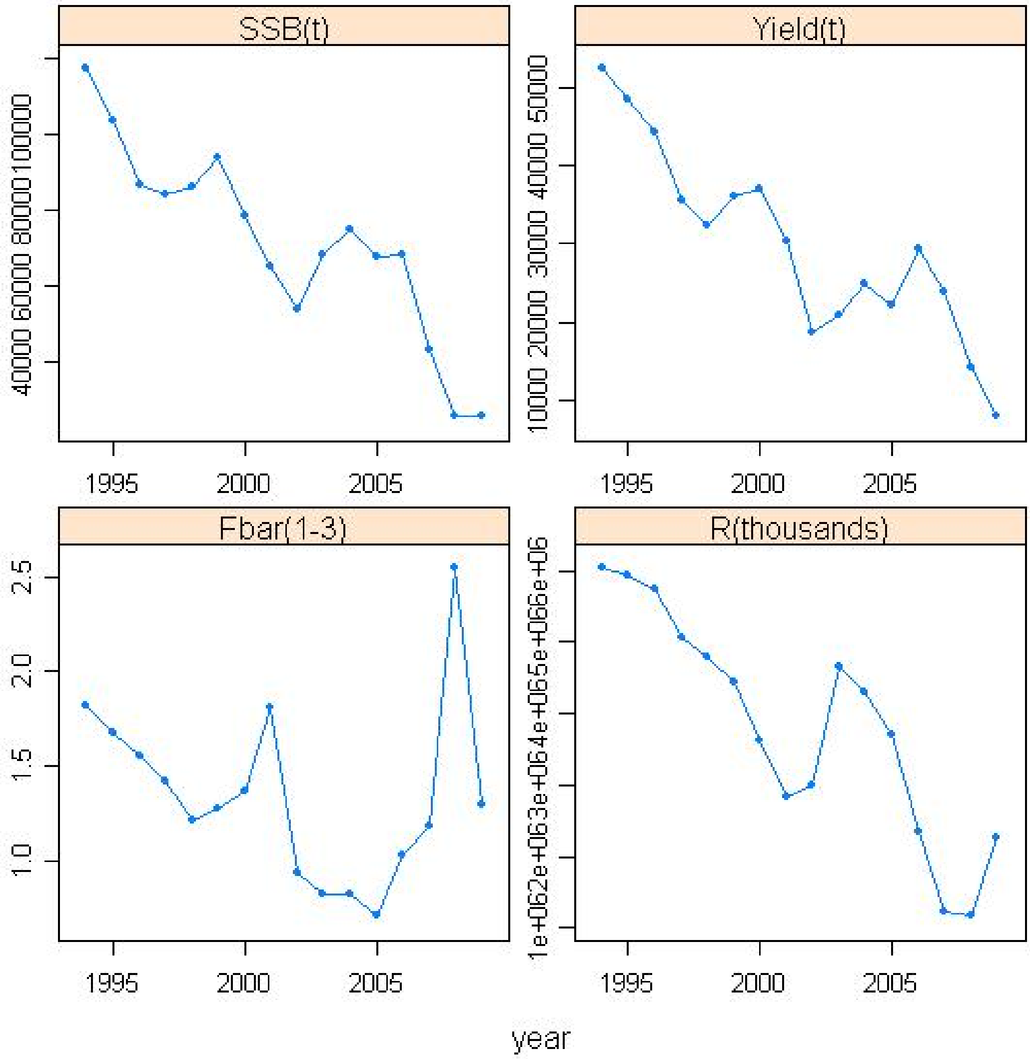


Fig. 5.48.4.1.3.3 Trends in estimated stock parameters.

Landings show a continuous and very sharp decrease from the beginning of the times series in 2002. Landings in 2009 were 7,900 t. This is the lowest observed values about half of what was observed in 2008 (14,120 t) which is the second lowest value of the time series. The annual landings of sardine (*Sardina pilchardus*) in the GSA 06 for the whole time series ranged between 52,440 and 7,900 t. The highest value corresponds to the first year analysed (1994 with 52,440 t).

F in 2009 (F_{0-2}=1.29) was lower than in 2008. Fishing mortality has decreased since the beginning of the time series till 2005 (F_{0-2} in 2005 = 0.70), with the exception of a peak in 2001. From 2005 the F increased, reaching its maximum in 2008 (F_{0-2} in 2008 =2.55).

Recruitment in 2009 (R09=2250 millions) increases compared to 2008 (1160 millions), the minimum of the time series.

SSB is has largely declined, reaching its minimum values in the recent years. Spawning Stock Biomass in 2009 (SSB=25,720 t) is practically the same of 2008 (SSB=25,450 t). The lowest observed SSB was in 2008 (SSB =25,450 t).

According to the results of the retrospective analysis, recruitment and SSB appear to be overestimated along the time series. Fbar appear to be underestimated, particularly for year 2008.

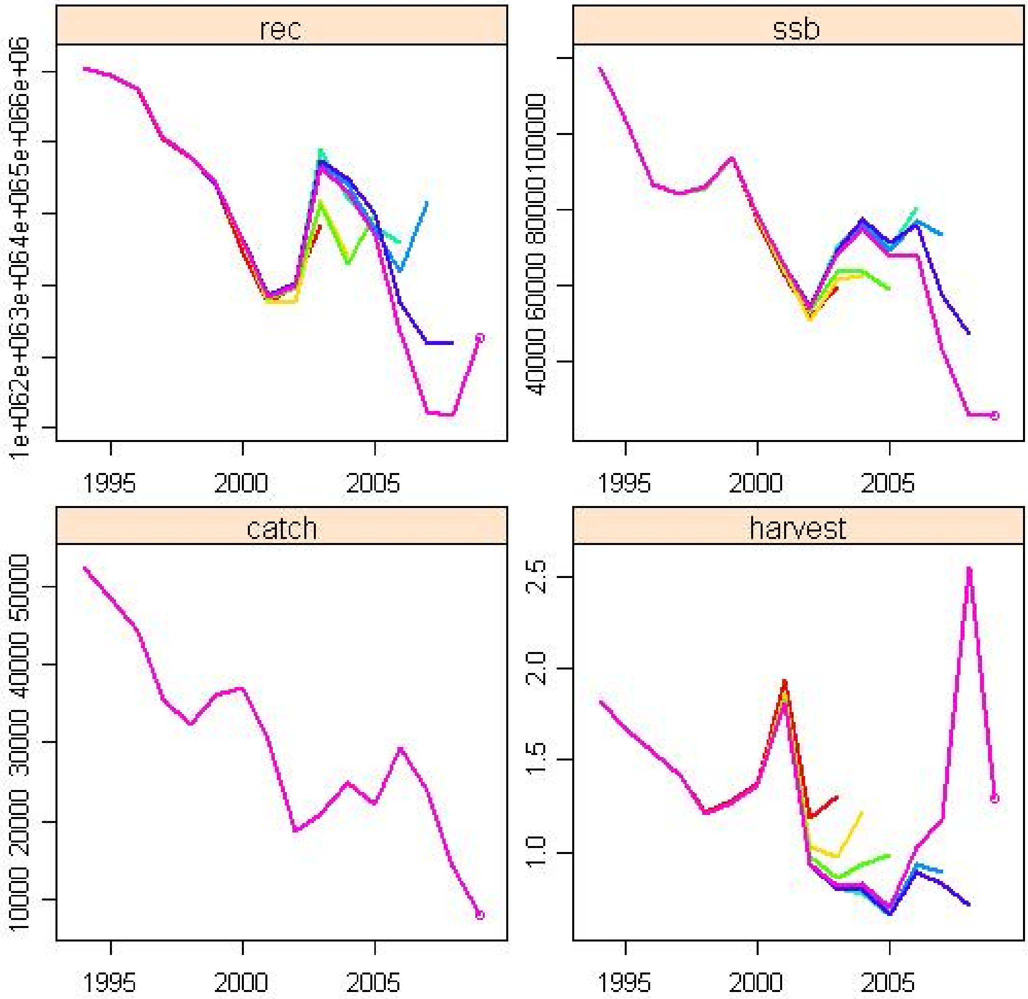


Fig. 5.48.4.1.3.4 Results of an retrospecitve analysis.

Patterson (1992) suggested an exploitation rate to assess the state of the resource as a potential reference point. This exploitation rate is calculated by F/Z. According our data, sardine GSA 06 is over exploited (Fig. 5.48.4.1.3.5). However we should note that this exploitation rate is highly dependent on the value of the natural mortality (M), so any interpretation of this exploitation rate should take into account that fact.

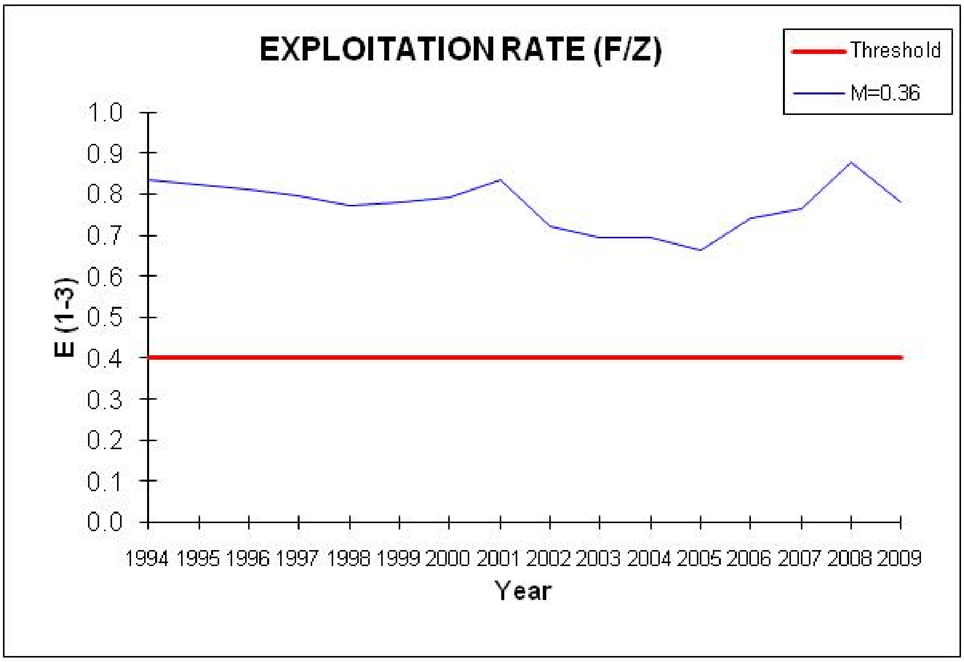


Fig. 5.48.4.1.3.5 Trend in estimated exploitation rates as compared with the proposed management reference point E=0.4.

5.48.5. Long term prediction

5.48.5.1.Justification

Yield-per-recruit analysis was carried out during SGMED-10-02. Yield per recruit analyses was conducted based on the exploitation pattern resulting from the XSA model and population parameters. Minimum and maximum ages for the analysis were considered to be age group 0 and 5, respectively. Stock weight at age, catch weight at age and maturity ogive was estimated as mean values between 2004 and 2009. Natural mortality vector values were applied per age group using ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Fishing mortalities were estimated as average of 2004-2009. Reference F was considered to be mean F for ages 0 to 2. Input parameters are shown in Tab. 5.48.5.2.1.

5.48.5.2.Input parameters

Tab. 5.48.5.2.1 YpR input parameters.

	age group	**stock weight**	**catch weight**	**maturity**	**F**	**M**
age min = 0	0	0.022	0.022	0.38	0.15	1.20
age max = 5	1	0.029	0.029	0.85	0.96	0.46
	2	0.038	0.038	0.99	1.45	0.34
Fref = 1.67	3	0.048	0.048	1	1.60	0.29
	4	0.059	0.059	1	1.05	0.26
	5	0.069	0.069	1	1.05	0.25

5.48.5.3.Results

Y/R analyses (Fig. 5.48.5.3.1) were not considered reliable due to its flat-topped shape. Therefore, $F_{0.1}$ cannot be used as a reference point for this stock. Also, the use of yield-per-recruit analysis for estimating targets for long-term management of pelagic fisheries has been discouraged (Patterson, 1992).

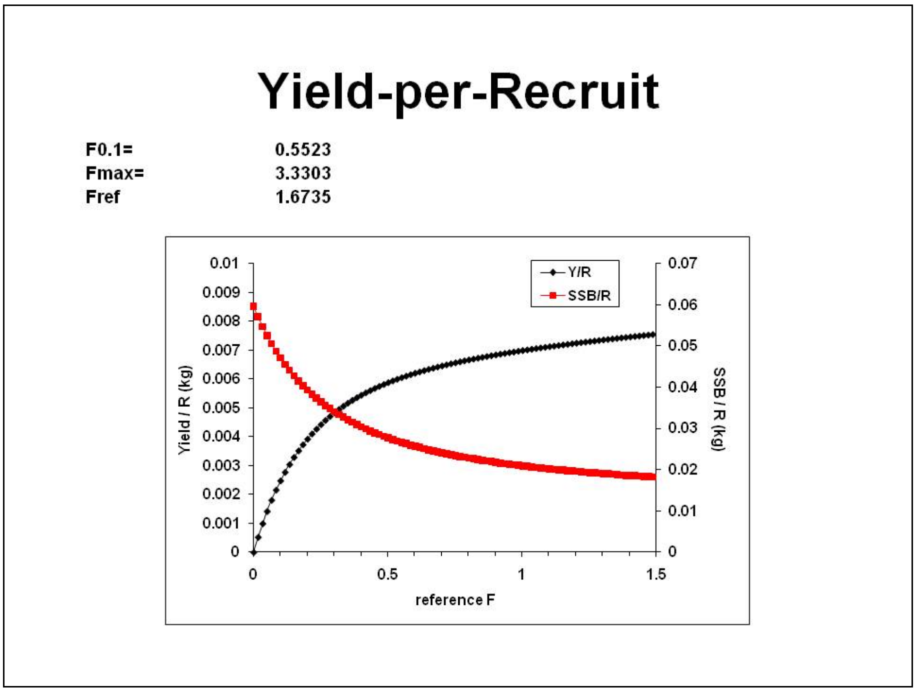


Figure 5.48.5.3.1. YPR analysis for sardine in GSA 06.

Tab. 5.48.5.3.1. Resulting parameters $F_{0.1}$ and F_{max} from the YpR analysis.

F0.1=	0.5523
Fmax=	3.3303
Fref	1.6735

5.48.6. Data quality and availability

No effort data were reported by Spain to SGMED-10-02 through the DCF data call. Thus, SGMED was unable to conduct an analysis of the effort trend for the major fleets fishing anchovy in GSA 6.

5.48.7. Scientific advice

5.48.7.1. Short term considerations

5.48.7.1.1. State of the spawning stock size

SSB is has largely declined, reaching its minimum values in the recent years. Spawning Stock Biomass in 2009 (SSB=25,720 t) is practically the same of 2008 (SSB=25,450 t), the lowest observed SSB values in the time series. No precautionaray reference points were proposed for biomass levels, and hence SGMED cannot comment on the state of the stock with this respect.

5.48.7.1.2. State of recruitment

Recruitment in 2009 (R09=2250 millions) increases compared to 2008 (1160 millions), the minimum of the time series considered. The trend of the recruitments is so important as they can affect seriously to the stock health. SGMED emphasises that the stock and the fishery is highly dependent on the recruitment strength.

5.48.7.1.3. State of exploitation

SGMED-10-02 proposes E=0.4 as limit management reference point consistent with high long term yields.

Fishing mortality has decreased since the beginning of the time series till 2005 (F_{0-2} in 2005 =0.70), with the exception of a peak in 2001. Since 2005, F increased, reaching its maximum in 2008 (F_{0-2} in 2008 =2.55).

The exploitation rate during the last five years (E=0.8) is estimated to exceed the exploitation reference points (E=0.4) proposed by Patterson (1992) and suggested by SGMED as an appropriate reference point for small pelagics.

Based on this assessment results the stock is considered overexploited. However, SGMED stresses that the use of the exploitation rate is very sensitive to M values.

It is important to stress that small pelagic fishery in GSA 06 is a multispecies fisheries and effort on anchovy and sardine should be considered together.

5.49. Stock assessment of sardine in GSA 16

Given that there were no data provided to update the stock assessment of sardine in GSA 16, SGMED-10-02 presents the assessment as conducted in 2009 by SGMED-09-02.

5.49.1. Stock identification and biological features

5.49.1.1. Stock Identification

This assessment of the sardine stock in GSA 16 is mainly based on information collected over the last decade relating fishery grounds off the southern Sicilian coast (GSA 16, South of Sicily), and specifically on biomass estimates obtained by hydroacoustic surveys and catch-effort data from local small pelagic fisheries. The main distribution area of the sardine stock in GSA 16 is the narrow continental shelf area between Mazara del Vallo and the southernmost tip of Sicily, Cape Passero (Patti *et al*., 2004).

5.49.1.2. Growth

Growth parameters were not used for this assessment.

5.49.1.3. Maturity

Maturity data were not used for this assessment.

5.49.2. Fisheries

5.49.2.1. General description of fisheries

In Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16, two operational units (OU) are presently active, purse seiners and pelagic pair trawlers. The fleet in GSA 16 is composed by about 50 units (17 purse seiners and 30 pelagic pair trawlers were counted up in a census carried out in December 2006). In both OUs, anchovy represents the main target species due to the higher market price.

5.49.2.2. Management regulations applicable in 2009 and 2010

Fisheries policy is strongly conditioned by EU regulations through the Common Fisheries Policy (CFP), based on the following principles: protection of resources; adjustment of (structure) facilities to the available resources; market organization and definition of relationships with other countries.

The main technical measures regulating fishing concern minimum landing size (9 cm for anchovy, 11 cm for sardine), mesh regulations (20 mm for pelagic pair trawlers, 14 mm for purse seiners) and restrictions on the use of fishing gear. Towed fishing gears are not allowed in the coastal area in less than 50 m depth, or within a distance of 3 nautical miles from the coastline. A seasonal closure for trawling, generally during summer-autumn, has been established since 1993. In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port: purse seiners (lampara vessels, locally known as “Ciancioli”) and midwaters pair trawlers (“Volanti a coppia”). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. Another fleet fishing on small pelagic fish species is based in some northern Sicilian ports and targets on juvenile stages (mainly sardines). Also this fishery is allowed for a limited period (usually one or two months during the winter season) by a special Regional law renewed year by year.

5.49.2.3. Catches

5.49.2.3.1. Landings

Landings were obtained within the framework of the census data collection carried out by IAMC-CNR (Mazara del Vallo) in Sciacca port since 1998. Information collected in the framework of CA.SFO. study project (Patti *et al*., 2007) showed that landings in Sciacca port account for about 2/3 of the total landings in GSA 16. Average sardine landings over the last decade (1997-2008) were about 1,500 metric tons, with a general decreasing trend.

It is worth noting that, though trend in biomass is clearly decreasing over the last years (Fig. 5.49.3.1.3.1.), landings levels over the same period were relatively high, indicating an increased vulnerability of the resource (Fig. 5.49.2.3.1.1).

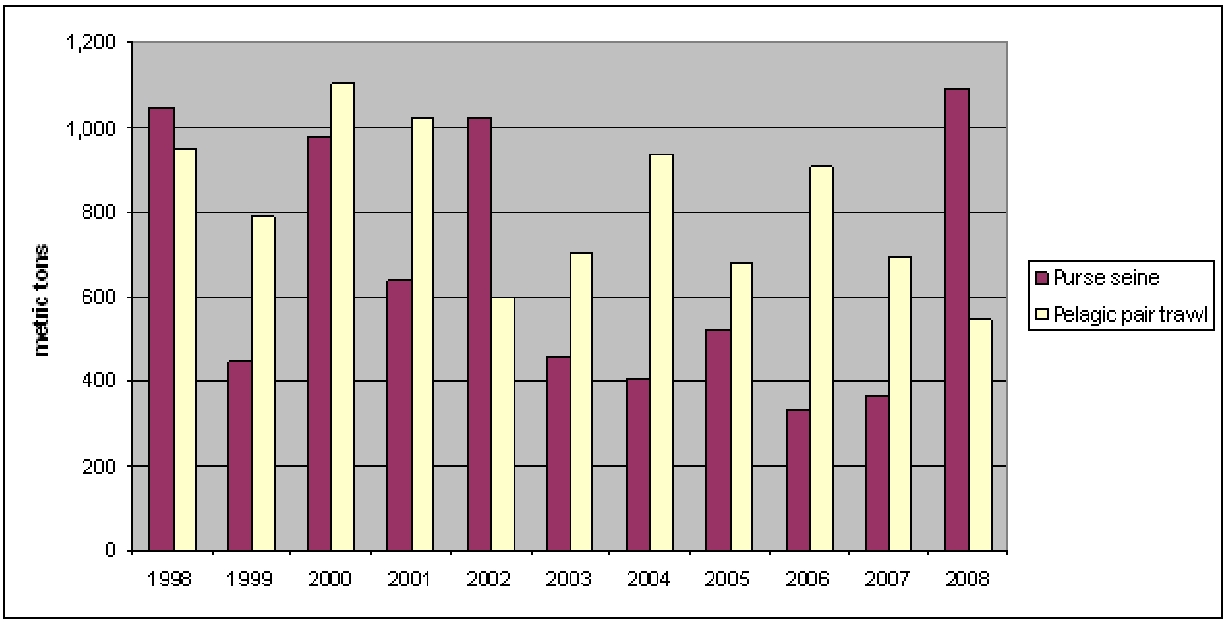


Fig. 5.49.2.3.1.1. Landings data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2008.

Tab. 5.49.2.3.1.1. Landings (t) as officially reported in 2010 through the DCF. No data for 2009 were submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
PIL	16	ITA	OTB	DEMSP				1		0	1	3	
PIL	16	ITA	OTB	MDDWSP					14	9	4		
PIL	16	ITA	PS	LPF				18		174			
PIL	16	ITA	PS	SPF				872	904	1543	1559	1622	
PIL	16	ITA	PTM	SPF					332	500	610	442	

5.49.2.3.2. Discards

No discards data for sardine were used for this assessment. However, discards are estimated to be less than 5% of total catch for both the pelagic pair trawl and the purse seine fisheries (Kallianiotis and Mazzola, 2002)

5.49.2.3.3. Fishing effort

Fishing effort data refer to census data collected in Sciacca port, the most important base port for the landings of small pelagic fish species along the southern Sicilian coast (GSA 16), accounting for about 2/3 of total landings in GSA 16.

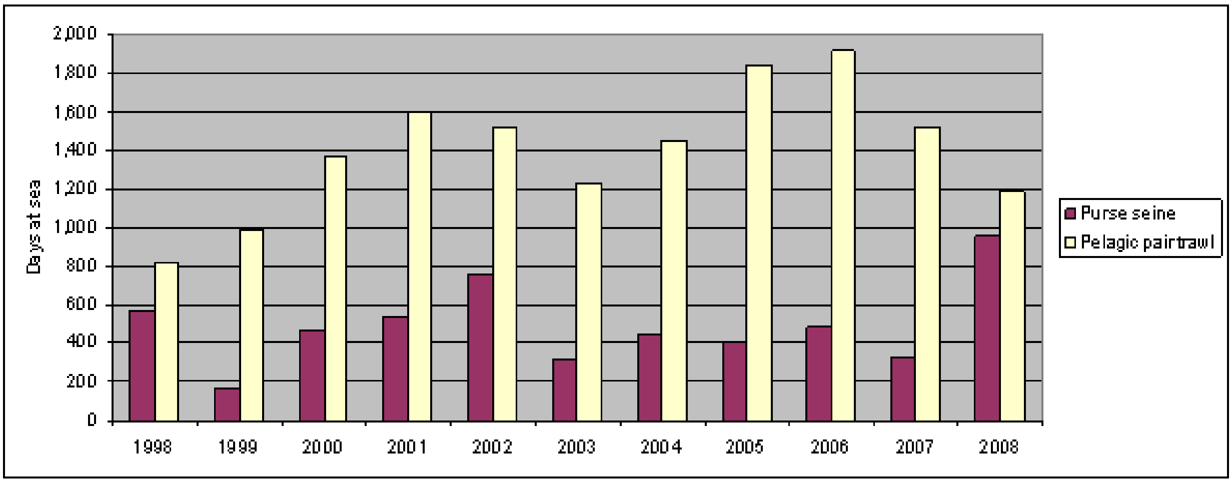


Fig. 5.49.2.3.3.1. Effort data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2008.

Tab. 5.49.2.3.3.1. Fishing effort (kW*days) as officially reported in 2010 through the DCF. No data for 2009 were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	SSEL_LENG	2003	2004	2005	2006	2007	2008	2009
16	ITA				VL0612			3886			417	
16	ITA	GTR	DEMSP		VL0006				8548	9979	12285	
16	ITA	GTR	DEMSP		VL0612		164944	178522	76073	103953	103352	
16	ITA	GTR	DEMSP		VL1218		25926	7720	23894	18868	8189	
16	ITA	GTR	DEMSP		VL1824			1420				
16	ITA	LHP-LHM	CEP		VL0006				525	1162		
16	ITA	LHP-LHM	FINF		VL0612		16931	16553	14973	15019	21934	
16	ITA	LHP-LHM	FINF		VL1218		641					
16	ITA	LLD	LPF		VL1218		12401	3900	2924	3435	16936	
16	ITA	LLD	LPF		VL1824		36304	5756	1029	78320	12919	
16	ITA	LLS	DEMF		VL0006				1022	3942	1394	
16	ITA	LLS	DEMF		VL0612		26733	58661	12698	57631	9512	
16	ITA	LLS	DEMF		VL1218		21984	1640	3115	62773	18439	
16	ITA	LLS	DEMF		VL1824		1870					
16	ITA	OTB	DEMSP		VL1218		210042	238629	272220		263191	
16	ITA	OTB	DEMSP		VL1824		54367	13425			397440	
16	ITA	OTB	DEMSP		VL2440						693213	
16	ITA	OTB	DWSP		VL1824						15246	
16	ITA	OTB	DWSP		VL2440						41113	
16	ITA	OTB	MDDWSP		VL1218					285378	4336	
16	ITA	OTB	MDDWSP		VL1824		377936	418914	434834	549867	93949	
16	ITA	OTB	MDDWSP		VL2440		1116269	1161841	442196	1484331	225904	
16	ITA	OTM	MDPSP		VL1824				21611	26555	41792	
16	ITA	OTM	MDPSP		VL2440		5306		9096			
16	ITA	PS	LPF		VL1824						9763	
16	ITA	PS	SPF		VL0006						397	
16	ITA	PS	SPF		VL0612			8471		670	3127	
16	ITA	PS	SPF		VL1218		1772	1997	1355		2354	
16	ITA	PS	SPF		VL1824		17339	12429	7349	39307	11625	
16	ITA	PTM	SPF		VL1824			19612	72116	107330	38857	

5.49.3. Scientific surveys

5.49.3.1. Acoustics

5.49.3.1.1. Methods

Acoustic surveys methodology

Steps for biomass estimation

- Collection of acoustic and biological data during surveys at sea;
- Extraction of $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) by means of Echoview (Sonar Data) post-processing software;
- Link of NASC values to control catches;
- Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data;
- Production of ρ distribution maps for different fish species and size classes;

– Integration of density areas for biomass estimation.

Collection of acoustic and biological data

Since 1998 the IAMC-CNR has been collecting acoustic data for evaluating abundance and distribution pattern of small pelagic fish species (mainly anchovy and sardine) in the Strait of Sicily (GSA 16). The scientific echosounder Kongsberg Simrad EK500 was used for acquiring acoustic data until summer 2005; for the echosurvey in the period 2006-2009 the EK60 echosounder was used. In both cases the echosounder was equipped with three split beam transducers pulsing at 38, 120 and 200 kHz. During the period 1998-2008 acoustic data were collected continuously during day and night time; since the 2009 echosurvey acoustic data are collected during day time, according to the MEDIAS protocol.

Before or after acoustic data collection a standard procedure for calibrating the three transducers was carried out by adopting the standard sphere method (Johannesson and Mitson, 1983).

Biological data were collected by a pelagic trawl net with the following characteristics: total length 78 m, horizontal mouth opening 13-15 m, vertical mouth opening 6-8 m, mesh size in the cod-end 10 mm. The net was equipped with two doors with weight 340 kg. During each trawl the monitoring system SIMRAD ITI equipped with trawl-eye and temp-depth sensors was adopted.

Extraction of $NASC_{Fish}$ by means of Echoview (Sonar Data) post-processing software

The evaluation of the $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) and the total NASC for each nautical mile of the survey track was performed by means of the SonarData Echoview software v3.50, taking into account the day and night collection periods.

Link of NASC values to control catches

For the echo trace classification the nearest haul method was applied, taking into account only representative fishing stations along transects.

Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data

For each trawl haul the frequency distribution of the *j*-th species (ν_j) and for the *k*-th lenght class (f_{jk}) are estimated as

$$\nu_j = \frac{n_j}{N} \qquad \text{and} \qquad f_{jk} = \frac{n_{jk}}{n_j}$$

where n_j is the total number of specimens of the *j*-th species, n_{jk} is the total number of specimens of the *k*-th lenght class in the *j*-th species, and N is the total number of specimens in the sample.

For each nautical mile the densities for each size class and for each fish species are estimated as

$$\rho_{jk} = \frac{NASC_{FISH} * n_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(number of fishes / n.mi}^2\text{)}$$

$$\rho_{jk} = \frac{NASC_{FISH} * W_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(t / n.mi}^2\text{)}$$

where W_{jk} is the total weight of the k-th lenght class in the j-th species, and σ_{jk} is the scattering cross section of the k-th lenght class in the j-th species. σ_{jk} *is given by*

$$\sigma_{spjk} = 4\pi * 10^{\frac{TS_{jk}}{10}}$$

where the target strenght (TS) is

$$TS_{jk} = a_j Log_{10}(L_k) + b_j$$

L_k is the length of the k-th lenght class while the a_j and b_j coefficient are linked to the fish species.

For anchovy, sardine and trachurus we adopted respectively the following relationships:

$TS = 20 \log L_k$ 76.1 [dB]
$TS = 20 \log L_k$ 70.51 [dB]
$TS = 20 \log L_k$ 72 [dB]

Integration of density areas for biomass estimation

The abundance of each species was estimated by integrating the density surfaces for each species.

5.49.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.49.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the sardine stock in GSA 16 was derived from the acoustics. Figure 5.49.3.1.3.1 displays the estimated trend in sardine Total Biomass (estimated by acoustics) for GSA 16.

Values of the last three years are relatively low, well below the general average value over the last decade (about 17,000 t).

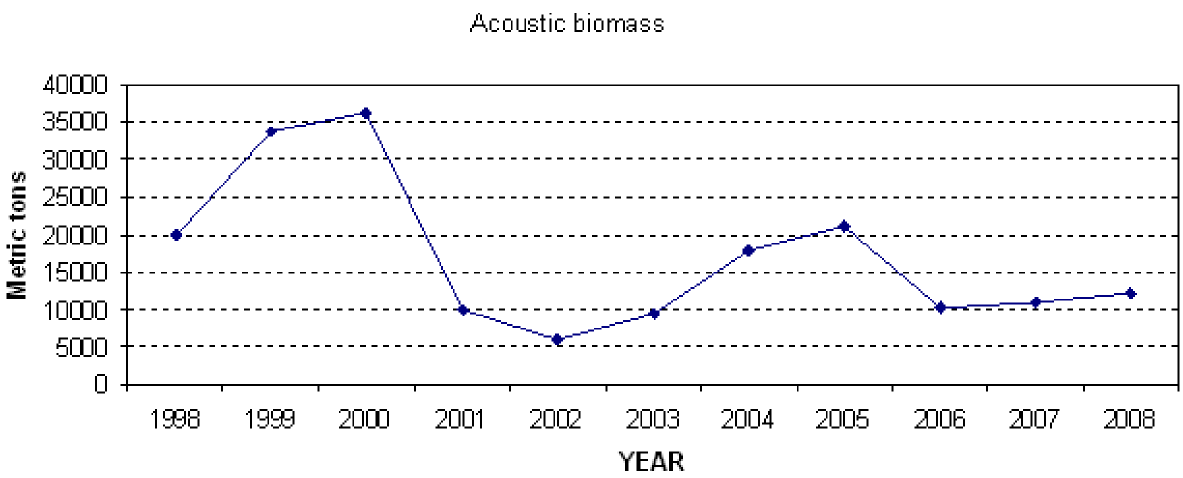


Fig. 5.49.3.1.3.1. Estimated sardine biomass indices for GSA 16, years 1998-2008.

5.49.3.1.4. Trends in abundance by length or age

Length or age class data were not used for this assessment.

5.49.3.1.5. Trends in growth

Growth data were not used for this assessment.

5.49.3.1.6. Trends in maturity

Maturity data were not used for this assessment.

5.49.4. Assessment of historic stock parameters

Not applicable. No stock assessment model was run for this assessment.

5.49.5. Long term prediction

Not applicable. No forecast analyses were conducted.

5.49.6. Scientific advice

5.49.6.1. Short term considerations

5.49.6.1.1. State of the spawning stock size

Biomass estimates of the total population obtained by hydro-acoustic surveys for sardine in GSA 16 show that the recent stock level has been well below the average value over the last decade until 2008. However, in the absence of proposed or agreed precautionary management reference points, SGMED-10-02 is unable to fully evaluate the state of the stock and provide any scientific advice in relation to them.

5.49.6.1.2. State of recruitment

No recruitment data were used for this assessment.

5.49.6.1.3. State of exploitation

SGMED-10-02 proposes the exploitation rate E=0.4 as limit management reference point consistent with high long term yield.

Annual exploitation rates, as estimated by the ratio between total landings and biomass, indicates relatively low fishing mortality during the last decade. If this estimate of exploitation rate can be considered as equivalent to F/Z estimate obtained from the fitting of standard stock assessment models, the current exploitation rate (0.22) and even all the previous available estimates are lower than the reference point suggested by Patterson (1992). The fishing mortality level corresponding to F/Z=0.22 is F=0.14, if M=0.51, estimated with Pauly (1980) empirical equation, is assumed.

Using the exploitation rate as a target reference point, the stock of sardine in GSA 16 is considered as being sustainably exploited until 2008.

Given that biomass was quite low for three consecutive years (2006, 2007 and 2008) and that the exploitation rate of sardine is moderate, fishing effort should not be increased beyond the current levels and consistent catches should be determined. However, as the small pelagic fishery is generally multispecies, any management of fishing effort targeting the anchovy stock (see above recommendations) would also have effects on sardine. In addition, due to the low level of the anchovy stock measures should be taken to prevent a shift of effort from anchovy to sardine.

General considerations

Taking into account that fishing effort was relatively stable in last decade, results would suggest the importance of environmental factors variability on yearly recruitment success. However, the stock did not recover from the 2006 "collapse" in biomass (-52% from July 2005 to June 2006), and this fact, along with a moderate exploitation rate and the decreasing trend in landings, also suggests questioning about the sustainability of current levels of fishing effort. In addition, possible negative effects on these populations could results from pressure of other fishing gears on larval stages.

A warning on the fishing of larval stages (locally named *bianchetto*) is relevant, taking into account that in the past years derogation of the fishing ban was normally operated in wintertime, i.e. during the sardine spawning season, even though more data and investigation are needed in order to estimate the possible impact of this fishing activity on the exploited populations.

5.50. Stock assessment of sardine in GSA 20

5.50.1. Stock identification and biological features

5.50.1.1. Stock Identification

This assessment of the sardine stock in GSA 20 has been based on information derived from the Greek part of the Ionian Sea (GSA 20). In the Ionian Sea, the main distribution area of the sardine stock includes coastal waters mainly located in Patraikos Gulf and in the area between the mainland and the islands of Leukas, Cephalonia and Corfu.

5.50.1.2. Growth

Since no other information was available the same growth parameters estimated in GSA 22 were also assumed for GSA 20. Fast growth parameter was considered and parameters are shown in Table 5.50.1.2.1. No sex discrimination was applied.

Table 5.50.1.2.1. Growth parameters (v. Bertalanffy) for sardine in GSA 20.

	Fast growth Unsexed	Units
Linf	195	cm
K	0.39	$year^{-1}$
t0	-0.48	year
a	0.00003	gr
b	3.2144	
Mage0	1.5	$year^{-1}$
Mage1	0.96	$year^{-1}$
Mage2	0.69	$year^{-1}$
Mage3	0.61	$year^{-1}$
Mage4	0.57	$year^{-1}$

5.50.1.3. Maturity

The following proportions of maturity at age were used for sardine assessments in GSA 20 as estimated from biological sampling (Machias et al., 2001; 2007). The sardine spawning period in GSA 20 extends from November to April with maximum in December-January.

Table 5.50.2.1.3.1 Maturity ogives at age for female sardine in GSA 20.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2003	0	0.5	1	1	1
2004	0	0.5	1	1	1
2005	0	0.5	1	1	1
2006	0	0.5	1	1	1
2007	0	0.5	1	1	1
2008	0	0.5	1	1	1

5.50.2. Fisheries

5.50.2.1.General description of fisheries

Sardine (*Sardina pilchardus*) is one of the most important target species for the purse seine fishery in GSA 20. Sardine is being exploited only by the purse seine fishery. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Commonly sardine is caught from shallow waters about 30 m to 100 m depth.

5.50.2.2.Management regulations applicable in 2009 and 2010

Regarding the management regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore (300m), minimum bottom depth (30 m), gear and mesh size, engine, GRT restrictions etc. There is also a minimum landing size at 11 cm.

5.50.2.3.Catches

5.50.2.3.1. Landings

The trend in reported landings (from Greek purse seiners fleet) is shown in Figs. 5.50.2.3.1.1 and 5.50.2.3.1.2. Landings were obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 20. The data from 2003 to 2006 and 2008 were reported to SGMED-10-02 through the Data Collection Regulation. Data for 2007 are unreported data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 20 A decreasing trend in sardine landings has been observed in the long term (2000-2008). Landings of the small vessels (12-24 m) (Fig. 5.50.2.3.1.2) are entirely responsible for sardine catches.

No length distribution of landings were reported to SGMED-10-02 for 2003-2008. Data were based on unreported data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers GSA 20.

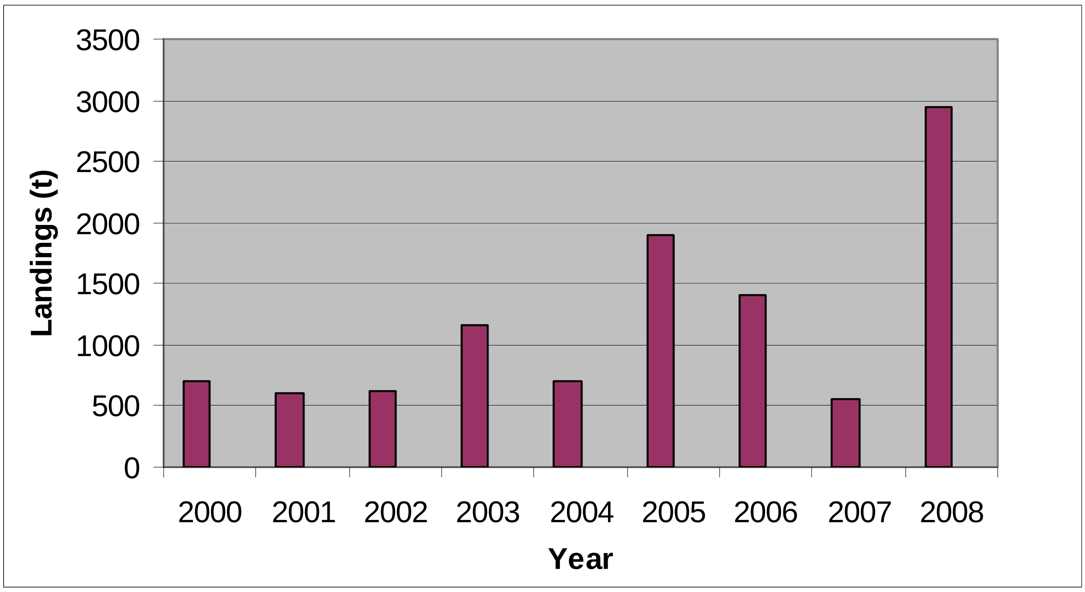


Fig. 5.50.2.3.1.1 Annual sardine landings (t) in GSA 20 for 2000-2008.

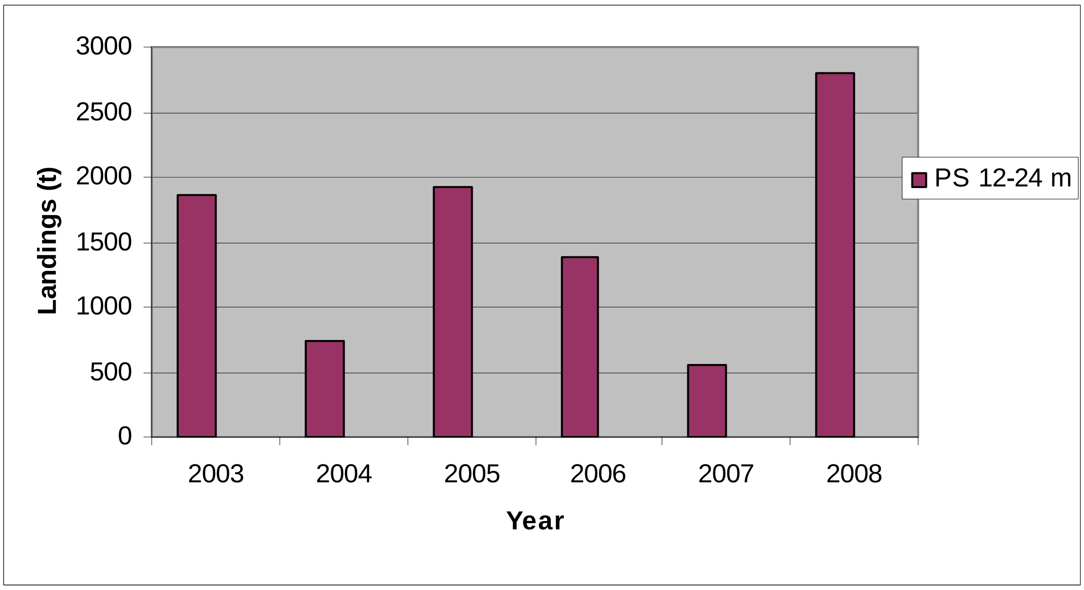


Fig. 5.50.2.3.1.2 Annual sardine landings (t) in GSA 20 of the purse seine fleet.

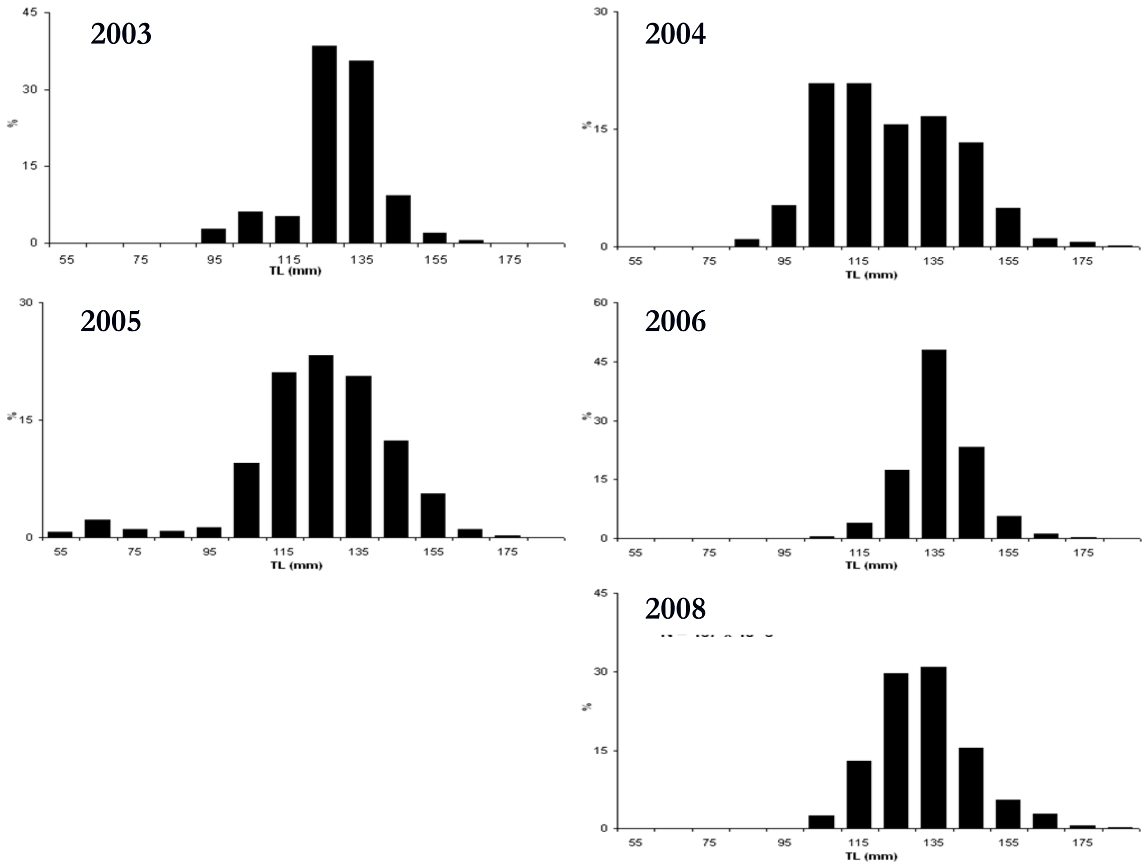


Fig. 5.50.2.3.1.3 Annual length frequency composition of sardine landings (t) in GSA 20 for 2003-2008.

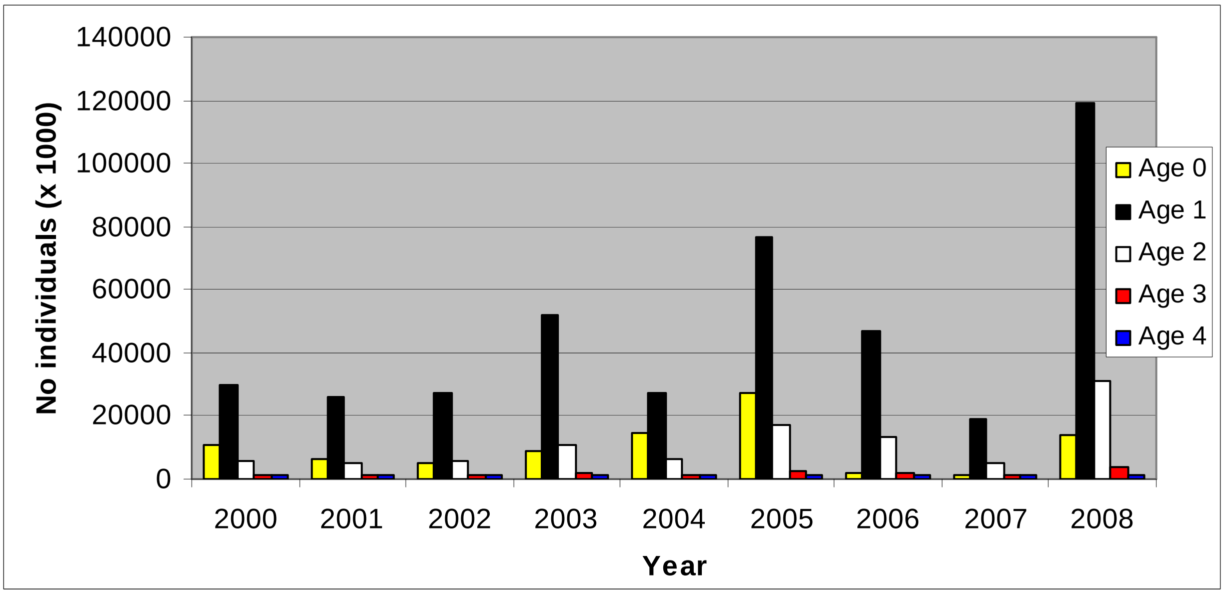


Fig. 5.50.2.3.1.4 Sardine landings per age group (No of individuals in thousands) for GSA 20 for 2000-2008.

5.50.2.3.2. Discards

No discards data for sardine were reported to the SGMED-10-02 and no data were reported through the Data collection regulation for 2003-2008. According to unreported data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 20, discards are estimated to less than 1%, consisting 0.3% of the purse seine fishery total catch. Although considered negligible they were taken into account for the assessment as a percentage to reported landings. The fishery is multispecies and fishermen tend to avoid schools of undersized sardines due to sorting difficulties (blocking of the mess) and low price, practically by using nets of bigger mesh size, targeting mostly mackerels or horse mackerels.

5.50.2.3.3. Fishing effort

Table 5.50.2.3.3.1 is based on the fishing effort data for GSA 20 collected under the DCF as well as data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 20. Although the active fleet remains at the same level, a change in the fleet was observed since 2005 with a pronounced increase in the vessels gross tonnage and vessels capacity.

Table 5.50.2.3.3.1 Effort data regarding the purse seine fleet in GSA 20. GRT=Gross tonnage, KW=engine horse power.

Year	PS 12-24 m				
	Active Fleet	Average Days at Sea	Total Days at Sea	Days at Sea x GRT	Days at sea x KW
2003	281	18.8	3377	66113	454877
2004	215	21.2	2604	54104	355157
2005	294	20.6	4342	163038	529175
2006	268	20.0	3782	128970	426087
2008	283	17.2	3982	111059	487907

5.50.3. Scientific surveys

No acoustic or DEPM scientific surveys were reported to SGMED-10-02 for sardine stock in GSA 20.

5.50.3.1.1. Methods

5.50.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.50.3.1.3. Trends in abundance and biomass

No analyses were conducted during SGMED-10-02.

5.50.3.1.4. Trends in abundance by length or age

No analyses were conducted during SGMED-10-02.

5.50.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02. Growth equation used was the one estimated and applied in GSA 22 in SGMED-09-02.

5.50.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-2. Maturity ogive estimates from GSA 22 based on biological sampling and length at first maturity estimates were used (Table 5.50.2.1.3.1).

5.50.4. Assessment of historic stock parameters

5.50.4.1. Method: XSA

5.50.4.1.1. Justification

Extended Survivors Analysis (XSA) for stock assessment (Shepherd, 1992) was applied. XSA uses virtual population analysis (VPA) (Pope & Shepherd, 1985) with weighted tuning indices. XSA focuses on the relationship between catch per unit effort and population abundance, allowing the use of a more complicated model for the relationship between CPUE and year class strength at the youngest ages. It was applied to the sardine stock in GSA 20 due to the lack of survey indices in the area that did not allow the application of the Integrated Catch at Age analysis as applied in the Greek part of GSA 22. In addition Y/R analysis was conducted during the SGMED-10-02.

5.50.4.1.2. Input parameters

XSA was based on commercial catch data (2000-2008) and tuned with CPUE of the purse seine fleet over the period 2003-2008.

Sardine data of annual sardine landings, annual sardine catch at age data (2000-2008), mean weights at age, maturity at age and the CPUE (2003-2008) presented in Table 5.50.4.1.2.2 to 5.50.4.1.2.4. Settings for the XSA model are summarized in Tab. 5.50.4.1.2.1. Different natural mortality values were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01 (Table 5.50.1.2.1). This method of the estimation of the natural mortality is consistent with the methodology used in GSAs 01, 06, 17 and 22 for small pelagics. Concerning the lack of acoustic information for 2007, average values were used concerning the maturity ogive and the weight at age in the stock.

Tab. 5.50.4.1.2.1. XSA settings.

Time series weights :	Tapered time weighting applied
Power =	3 over 6 years
Catchability analysis	
Catchability independent of size for ages	> 2
Catchability independent of age for ages	> 3
Terminal population estimation :	
Survivor estimates shrunk towards the mean F	of the final 6 years or the 2 oldest ages
S.E. of the mean to which the estimates are shrunk =	0.5
Minimum standard error for population estimates derived from each fleet =	0.3
prior weighting	not applied

Table 5.50.4.1.2.2. Catch at age (numbers in thousands) of sardine stock in GSA 20 for 2000-2008.

Year	0	1	2	3	4
2000	10838	29650	5827	1376	1006
2001	6085	25971	5317	1368	1008
2002	5320	27057	5579	1366	1007
2003	8615	52229	11066	1671	1010
2004	14333	27159	6086	1565	1023
2005	27347	76349	17269	2448	1037
2006	2192	47190	13234	2099	1029
2007	1304	19115	5250	1449	1013
2008	14252	118828	31000	3842	1094

Table 5.50.4.1.2.3. Catches estimates (in t) of sardine stock in GSA 20 for 2000-2008.

Year	Sardine
2000	706
2001	611
2002	617
2003	1159
2004	698
2005	1900
2006	1402
2007	561
2008	2943

Table 5.50.4.1.2.4. Weight at age in the catch of sardine stock (in kg) in GSA 20 for 2000-2008.

	Age 0	Age 1	Age 2	Age 3	Age 4
2000	0.0097	0.0178	0.0222	0.0283	0.0565
2001	0.0110	0.0182	0.0223	0.0264	0.0294
2002	0.0107	0.0184	0.0217	0.0257	0.0297
2003	0.0102	0.0185	0.0210	0.0248	0.0303
2004	0.0091	0.0179	0.0257	0.0328	0.0492
2005	0.0087	0.0183	0.0243	0.0302	0.0378
2006	0.0150	0.0217	0.0246	0.0285	0.0390
2007	0.0141	0.0212	0.0248	0.0296	0.0434
2008	0.0112	0.0173	0.0222	0.0288	0.0447

Tab. 5.50.4.1.2.5. CPUE for age group of sardine (kg/days at sea) stock in GSA 20 for 2003-2008. Age 3 was considered a plus age group.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**
Age 1	255	164	291	268	100	483
Age 2	61	53	88	85	32	161
Age 3+	4	7	9	9	4	22

5.50.4.1.3. Results including sensitivity analyses

The residual plot of the catchability per age and year of the model shown in Fig. 5.50.4.1.3.1 generally showed good model fit besides the residuals at age 1 in 2007.

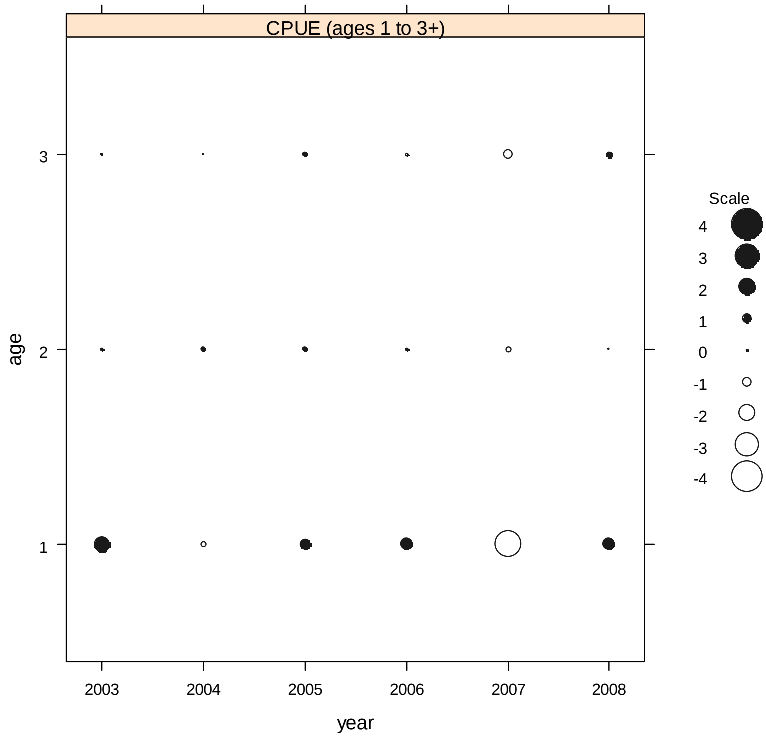


Fig. 5.50.4.1.3.1 Residual plot of index catchabilities per age and year of sardine XSA model for GSA 20 (2003-2008).

The model diagnostics are also shown in Table 5.50.4.1.3.1

Table 5.50.4.1.3.1. Model diagnostics.

Regression weights

2000	2001	2002	2003	2004	2005	2006	2007	2008
-2.573	-0.203	0	0.075	0.348	0.67	0.893	0.986	1

Fleet: CPUE (ages 1 to 3+)

Log catchability residuals.

	2003	2004	2005	2006	2007	2008
1	2.159	-0.548	1.496	1.595	-3.993	1.542
2	0.26	0.321	0.382	0.206	-0.543	-0.035
3	0.02	-0.018	0.473	0.275	-1.114	0.54

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Mean_Logq S.E_Logq
-6.1015 0.6046

Regression statistics

	Ages with q dependent on year class strength	slope intercept
Age 1	1.929411	0.412363
Age 2	0.884325	6.142842

Terminal year survivor and F summaries:

	scaledWts	survivors	yrcls
Age 0 Year class =2008			
fshk	1	225234	2008
Age 1 Year class =2007			
CPUE (ages 1 to 3+)	0.029	200524	2007
fshk	0.971	88041	2007
Age 2 Year class =2006			
CPUE (ages 1 to 3+)	0.198	18179	2006
fshk	0.802	19839	2006
Age 3 Year class =2005			
CPUE (ages 1 to 3+)	0.152	5071	2005
fshk	0.848	2953	2005

Table 5.50.4.1.3.2 Estimated fishing mortality at age, 2000-2008.

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Age 0	0.059	0.024	0.018	0.028	0.030	0.079	0.004	0.001	0.027
Age 1	0.748	0.696	0.479	0.942	0.383	0.814	0.671	0.133	0.560
Age 2	0.729	0.643	0.711	0.863	0.582	1.105	0.728	0.296	0.738
Age 3	0.739	0.669	0.595	0.903	0.481	0.923	0.664	0.264	0.649
Age 4	0.739	0.669	0.595	0.903	0.481	0.923	0.664	0.264	0.649

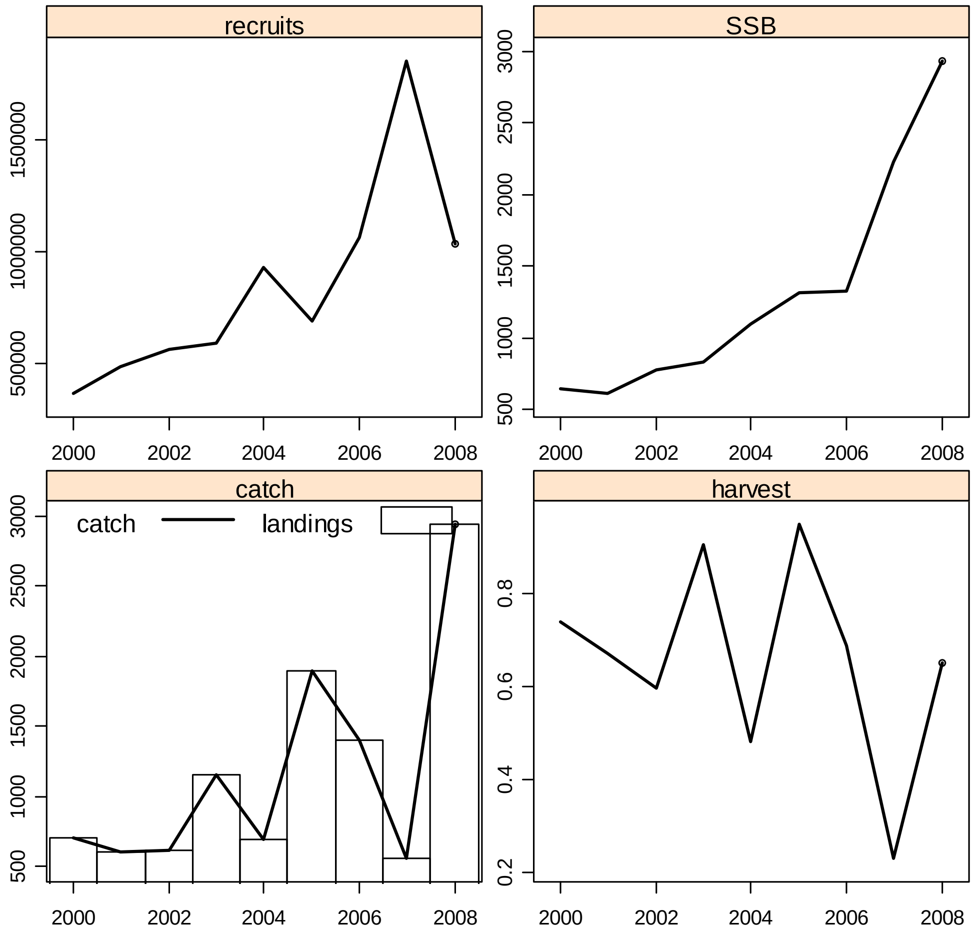
Table 5.50.4.1.3.3 Estimated stock numbers at age (thousands), 2000-2008.

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Age 0	363088	489024	565639	594141	925886	691248	1059530	1851480	1036855
Age 1	82655	76380	106502	123924	128872	200440	142567	235469	412559
Age 2	14967	14973	14582	25251	18491	33643	34015	27896	78892
Age 3	3394	3623	3949	3591	5341	5185	5589	8238	10407
Age 4	2481	2669	2911	2171	3492	2196	2740	5760	2963

Table 5.50.4.1.3.4 Summary table of stock parameters as estimated by XSA, 2000-2008.

Year	Recruits	Total Biomass (tonnes)	Spawning Biomass (tonnes)	Landings (tonnes)	Yield/SSB ratio	F1-3	E
2000	362	5562	1302	706	0.54	0.74	0.50
2001	485	7277	1199	611	0.51	0.67	0.47
2002	562	8516	1474	617	0.42	0.60	0.45
2003	587	9038	1815	1159	0.64	0.92	0.55
2004	922	11555	1944	698	0.36	0.49	0.40
2005	667	10739	2863	1900	0.66	0.97	0.56
2006	1055	20090	2572	1402	0.54	0.72	0.49
2007	1825	32284	3613	561	0.15	0.24	0.25
2008	1015	20934	5651	2943	0.52	0.68	0.48

XSA model results for sardine stock in GSA 20 are shown in Fig. 5.50.4.1.3.2, indicating an increasing trend for spawing biomass since 2004. Similarly an increasing trend was observed for recruitment since 2005 but with a decrease in 2008 at the level of approximately 1000 (x10^6) individuals. F mean (ages 1 to 3) seems to be highly variable presenting a decrease since 2005.



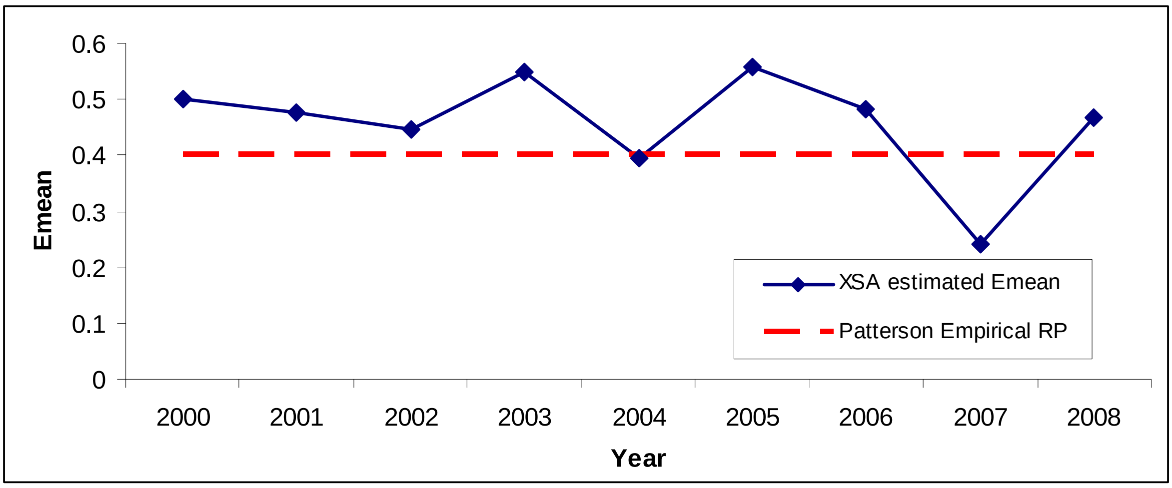
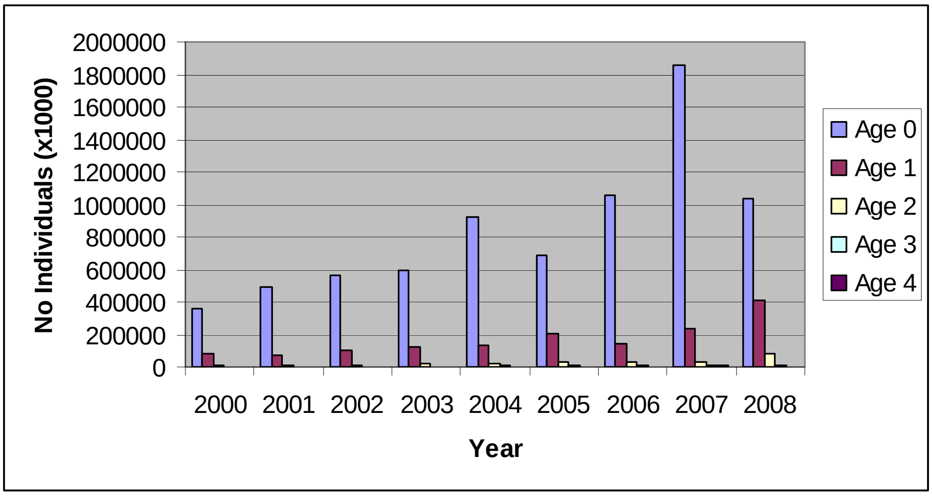


Fig. 5.50.4.1.3.2 Sardine XSA Model (M variable per age group based on ProBiom estimations, CPUE index) results: Recruitment, SSB, Total biomass, Fmean for ages 1-3 and exploitation rate (F/Z).



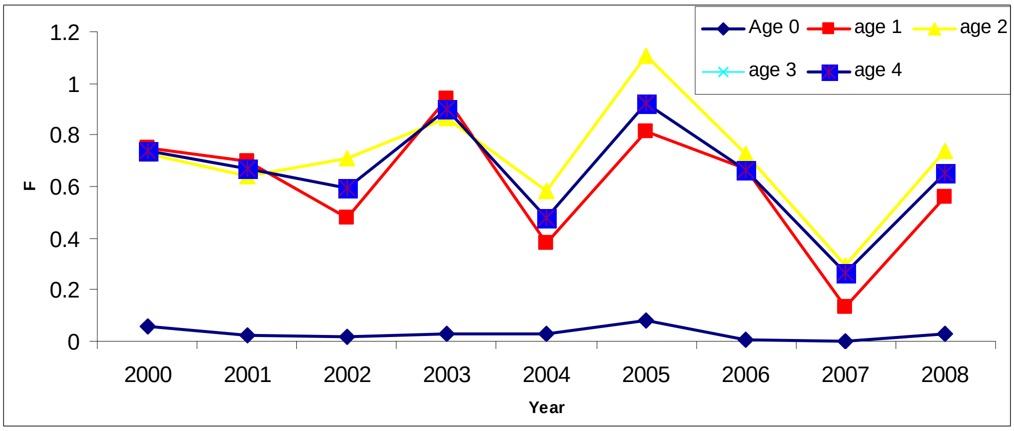


Fig. 5.50.4.1.3.3 Sardine XSA Model (M variable per age group based on ProBiom estimations, CPUE index) results: Population at age, F at age.

Bootstrapping of the XSA model was also applied with 100 iterations in order to have an estimation of the uncertainty in the SSB, recruitment and Fbar estimates. Results are presented in figure Fig. 5.50.4.1.3.4

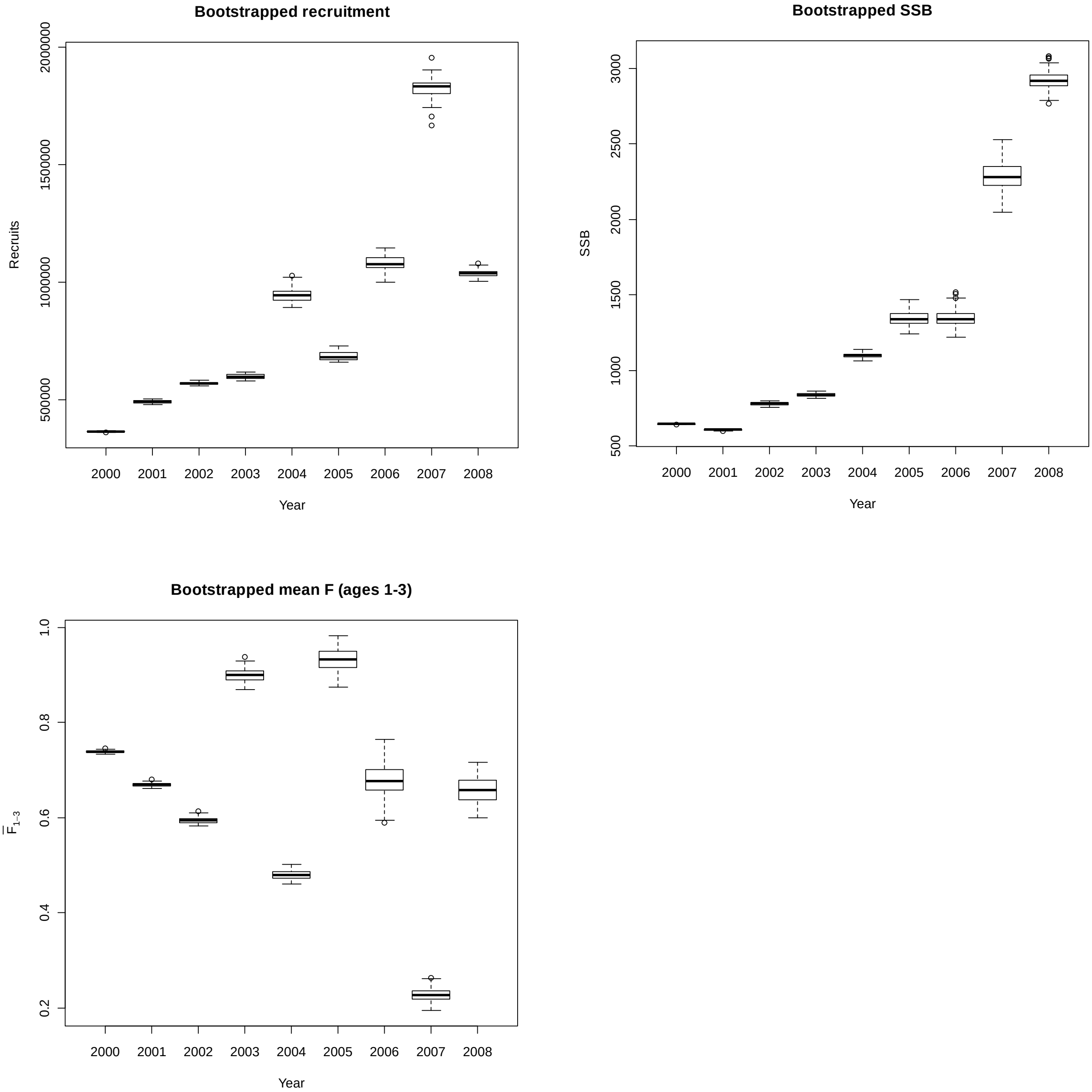


Fig. 5.50.4.1.3.4 Sardine XSA Model (M variable per age group based on ProBiom estimations, CPUE index) results: Bootstrapped Recruitment, Bootstrapped SSB and bootstrapped Fmean for ages 1-3.

Retrospective analysis was applied in the XSA model for the sardine in GSA 20 and the period 2000-2008 up to 5 years backward analysis. Results are presented in Fig. 5.50.4.1.3.5 showing large retrospective errors for all stock estimates.

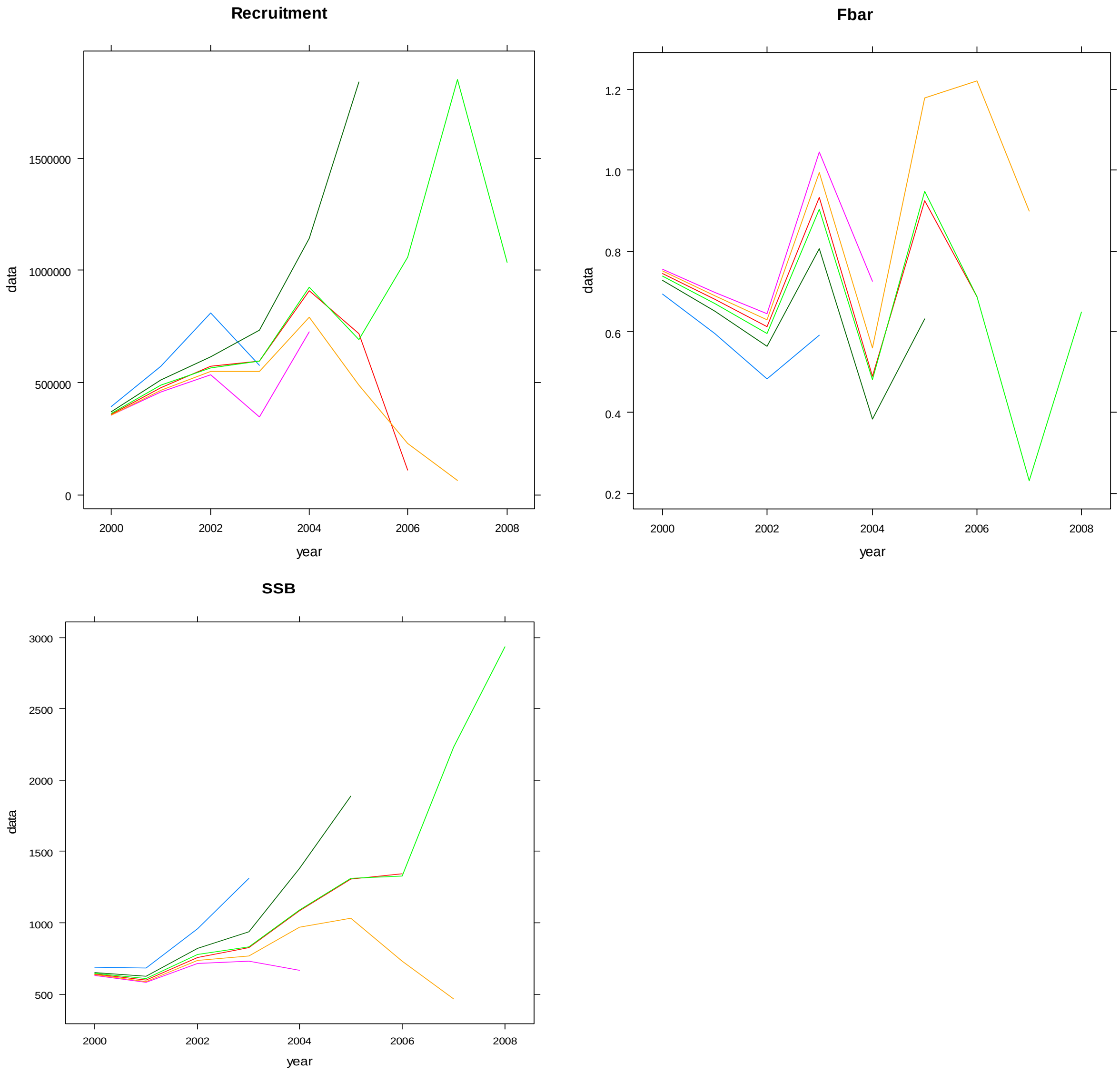


Fig. 5.50.4.1.3.5 The results of retrospective analysis of the XSA model applied in GSA 20 sardine stock for the 2000-2008, concerning F mean 1-3, SSB and recruitment.

5.50.5. Long term prediction

5.50.5.1. Justification

Yield per recruit analysis was conducted in the SGMED-10-02 assuming equilibrium conditions.

5.50.5.2. Input parameters

Based on the exploitation pattern resulting from the XSA model and its population parameters, yield per recruit analyses were formulated. Minimum and maximum age for the analysis were considered to be age group 0 and 4, respectively. Stock weight at age, catch weight at age and maturity ogive were estimated as mean values in a long term basis (2000-2008). Natural mortality were based on ProBiom estimations.

Fishing mortalities were estimated in a short term basis (2004-2008). Reference F was considered to be mean F for ages 1 to 3. Input parameters are shown in Table 5.50.5.2.1.

Table 5.50.5.2.1. Input parameters for Y/R analysis.

age group	stock weight	catch weight	maturity	F	M
0	0.011	0.011	0	0.0301	1.50
1	0.019	0.019	0.5	0.6031	0.96
2	0.023	0.023	1	0.7105	0.69
3	0.028	0.028	1	0.6542	0.61
4	0.040	0.040	1	0.6542	0.57

5.50.5.3.Results

Y/R analysis was performed (Fig. 5.50.5.3.1) but was not considered reliable due to its flat-topped shape. Therefore the use of $F_{0.1}$ (1.6) cannot be used as a reference point for this stock.

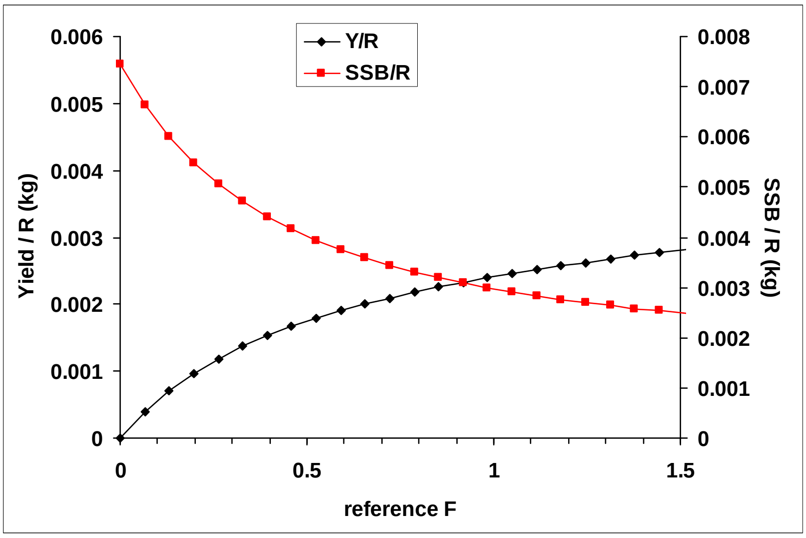


Fig. 5.50.5.3.1. Yield per recruit for the sardine stock in GSA 20.

5.50.6. Data quality and availability

The data collected in 2003 to 2006 and 2008 although reported to SGMED-10-02 through the Data Collection Framework (DCF) did not include discards estimations. Data from 2007 were missing (DCF was not carried out) so input data were based on unreported data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers GSA 20. Data for 2009 were not available as DCF was not carried out in Greece last year. No length distribution of landings were reported to SGMED-10-02 for 2003-2008.

The lack of fishery independent information to be used as tuning fleet in the assessment, XSA model the unstandardised CPUE of the purse seine fleet was used to tune the XSA. However, since the purse seine fleet showed a sharp increase in capacity since 2005, SGMED consider that this could result into an underestimation of the exploitation rate. SGMED also underline the need of conducting data collection and surveys on an annual basis to allow for the assessment of the stock in the future.

5.50.7. *Scientific advice*

5.50.7.1. Short term considerations

5.50.7.1.1. State of the spawning stock size

Estimates of XSA stock assessment model for sardine in GSA 20 indicated an increase since 2004 reaching 5,600 t in 2008. In the absence of proposed or agreed references, SGMED-10-02 is unable to fully evaluate the state of the stock and provide scientific advice in respect to precautionary biomass reference points.

5.50.7.1.2. State of recruitment

XSA model estimates had showed an increase in the number of recruits towards 2007 but a decrease was estimated by the stock assessment model in 2008.

5.50.7.1.3. State of exploitation

SGMED proposes E=0.4 as limit management reference point consistent with high long term yield.

Based on XSA results, the mean fishing mortality (averaged over ages 1 to 3) is highly variable, being below 1 in all years and decreasing since 2005 but approximating 0.68 in 2008. However, since XSA was tuned with unstandardised CPUE of the purse seine fleet, exploitation rates might be underestimated. The purse seine fleet showed a sharp increase concerning its capacity since 2005 that might bias the model estimates, resulting into underestimation of the exploitation rate.

The exploitation rate below the empirical level for stock decline (E<0.4, Patterson 1992) was suggested by the SGMED-10-02 as reference point for small pelagics. Therefore, the mean F/Z concerning the sardine stock in GSA 20 was on average above (mean value of the entire time series equals 0.46) the empirical level of sustainability (E<0.4, Patterson 1992) for small pelagics. Taking into account that this value could be an underestimation of the actual situation, the SGMED recommend a reduction in fishing mortality in order to reach the F/Z= 0.4, promote stock recovery and avoid future loss in stock productivity and landings.

Fishing mortality should be reduced in order to allow future recruitment contributing to stock productivity. This requires also consideration of the mixed fisheries nature of the fleets.

5.51. Stock assessment of sardine in GSA 22

Given that there were no data provided to update the stock assessment of sardine in GSA 22, SGMED-10-02 presents the assessment as conducted in 2009 by SGMED-09-02.

5.51.1. Stock identification and biological features

5.51.1.1. Stock Identification

This assessment of the sardine stock in GSA 22 has been based on information derived from the Greek part of the Aegean Sea (GSA 22). In Aegean Sea, the main distribution area of the sardine stock of GSA 22 is located in the continental shelf of the northern Aegean Sea (Giannoulaki *et al.*, 2004; 2007; Machias *et al.*, 2007; Tsagarakis *et al.*, 2008). Sardine juveniles spatial distribution is strongly related to semi closed gulfs, shallow waters (less than 30 m depth) with high productivity, influenced by the presence of rivers outflows (Tsagarakis *et al.*, 2007; SARDONE project interim report).

5.51.1.2. Growth

Fast growth parameter was considered and parameters are shown in Table 5.51.1.2.1. No sex discrimination was applied.

Tab. 5.51.1.2.1. Growth parameters (v. Bertalanffy) for sardine in GSA 22.

	Fast growth Unsexed	Units
Linf	195	cm
K	0.39	$year^{-1}$
t0	-0.48	year
a	0.00003	gr
b	3.2144	
Mage0	1.5	$year^{-1}$
Mage1	0.96	$year^{-1}$
Mage2	0.69	$year^{-1}$
Mage3	0.61	$year^{-1}$
Mage4	0.57	$year^{-1}$

5.51.1.3. Maturity

The following maturity at age ogive was used for sardine assessments in GSA 22 as estimated from biological sampling based on length at first maturity estimated approximately at 115 mm (Machias *et al.*, 2001; 2007) in Aegean Sea. The sardine spawning period in GSA 22 extends from November to April with a peak in December-January.

Tab. 5.51.1.3.1 Maturity ogives at age for female sardine in GSA 22.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2003	0	0.5	1	1	1
2004	0	0.5	1	1	1
2005	0	0.5	1	1	1
2006	0	0.5	1	1	1
2007	0	0.5	1	1	1
2008	0	0.5	1	1	1

5.51.2. Fisheries

5.51.2.1. General description of fisheries

Sardine (*Sardina pilchardus*) is one of the most important target species for the purse seine fishery in GSA 22. Sardine is being exploited only by the purse seine fishery. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Commonly sardine is caught from shallow waters about 30 m to 100 m depth.

5.51.2.2. Management regulations applicable in 2009 and 2010

Regarding the management regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore (300 m), minimum bottom depth (30 m), gear and mesh size, engine, GRT restrictions etc. There is also a minimum landing size at 11 cm.

5.51.2.3. Catches

Landings were obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22. The data from 2003 to 2008 were reported to SGMED-10-02 through the Data Collection Regulation.

5.51.2.3.1. Landings

The trend in reported landings (from Greek purse seiners fleet) is shown in Figs. 5.51.2.3.1.1 and 5.51.2.3.1.2. The data from 2003 to 2006 and 2008 were reported to SGMED-10-02 through the Data Collection Regulation. The rest of the data are obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22. A decreasing trend in sardine landings has been observed in the long term (2000-2008). Landings per vessel class indicate that small vessels (12-24 m) (Fig. 5.51.2.3.1.2) are mainly responsible for sardine catches (> 88% of the total catches).

Annual lengths of landings were reported to SGMED-10-02 for 2003-2006 and 2008 and are shown in Fig. 5.51.2.3.1.3. Fig. 5.51.2.3.1.4 shows the landings at age in GSA 22 for 2003-2006. Data for 2007 and 2008 are based on unreported data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22.

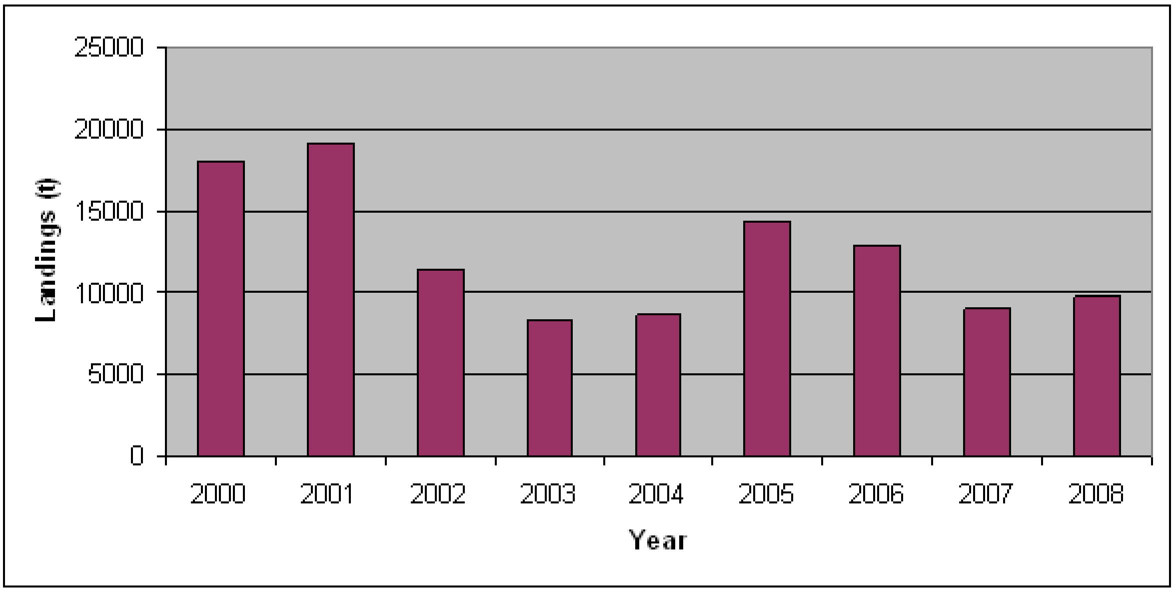


Fig. 5.51.2.3.1.1 Sardine landings (t) in GSA 22 for 2000-2008.

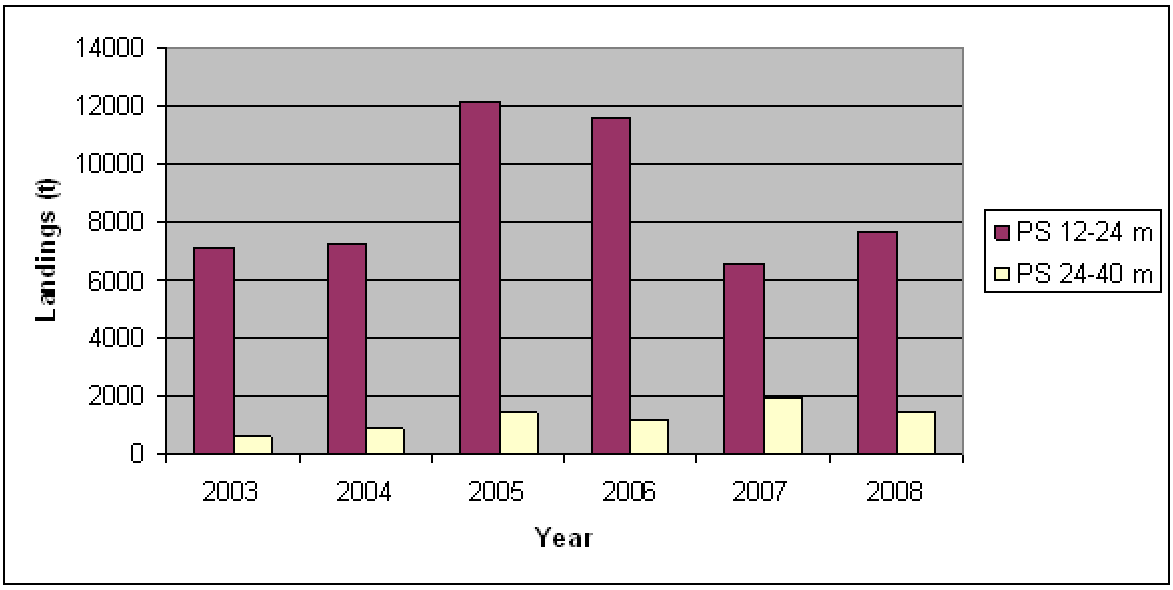


Fig. 5.51.2.3.1.2 Sardine landings (t) in GSA 22 per fleet size (purse seine fleet in Greek waters) for 2003-2008.

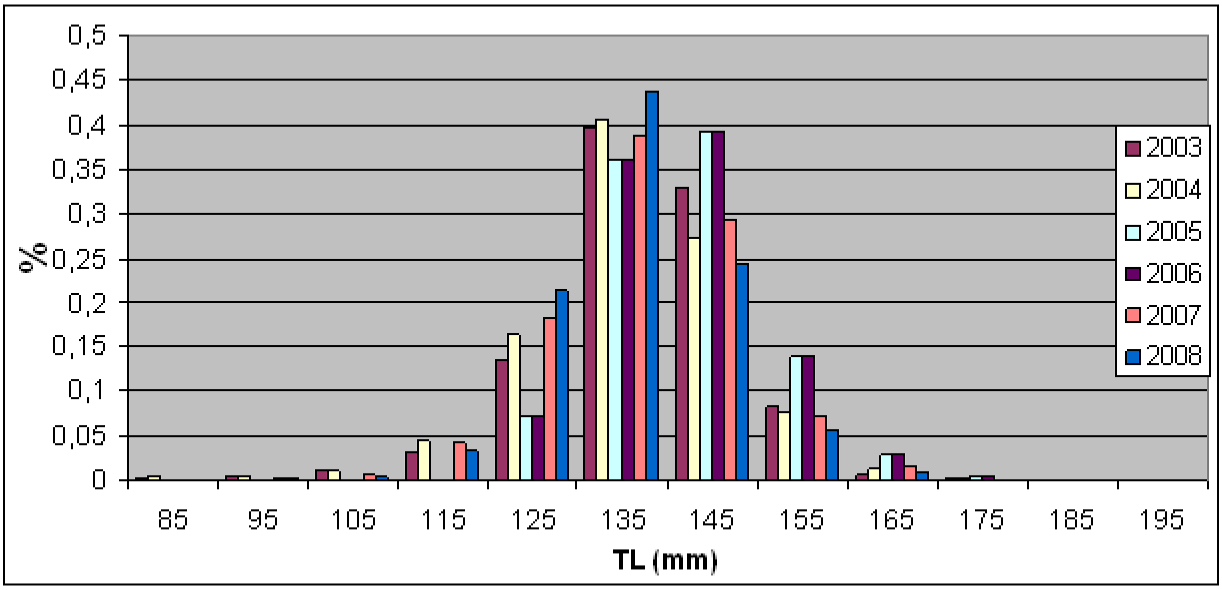


Fig. 5.51.2.3.1.3 Length frequency composition of sardine landings for 2003-2008.

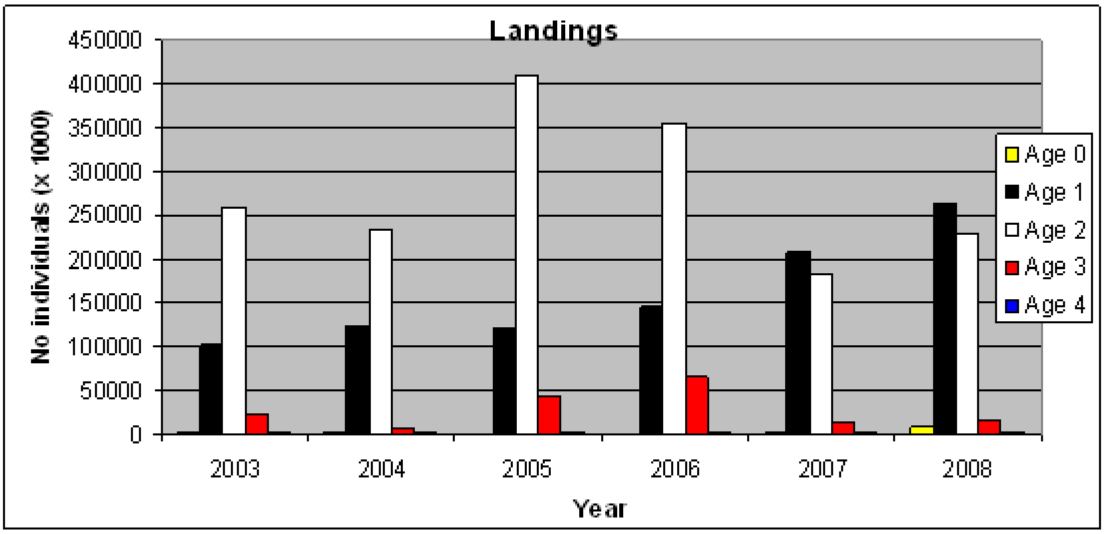


Fig. 5.51.2.3.1.4 Sardine landings per age group (number of individuals in thousands) for GSA 22 for 2003-2008.

5.51.2.3.2. Discards

No discards data for sardine were reported to the SGMED-10-02 and no data were reported through the Data collection regulation for 2003-2008. According to data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22, discards are estimated to less than 1%, consisting 0.3% of the purse seine fishery total catch. Although considered negligible they were taken into account for the assessment as a percentage to reported landings. The fishery is multispecies and fishermen tend to avoid schools of undersized sardines due to sorting difficulties (blocking of the mesh) and low price, practically by using nets of bigger mesh size, targeting mostly mackerels or horse mackerels.

5.51.2.3.3. *Fishing effort*

Based on the fishing effort data reported through the Data collection regulation and data obtained within the framework of the Hellenic Centre for Marine Research data collection system covering the entire GSA 22, the following table was made:

Tab. 5.51.2.3.3.1 Effort data for the purse seine fleet in GSA 22 (GT=Gross tonnage, KW=engine power).

Year	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m
	Days at Sea	**Days at Sea**	**Days at Sea x GT**	**Days at Sea x GT**	**Days at Sea x KW**	**Days at Sea x KW**
2003	41539	2942	1767398	230726	8709727	679624
2004	39783	3989	1620847	366709	8111571	1029410
2005	42520	5690	1753346	542120	8123673	1532790
2006	37255	5619	1568893	539146	7386042	1606608
2007	31492	5338	1305252	524544	6511187	1528440
2008	35090	4938	1457212	473121	6898061	1335582

5.51.3. *Scientific surveys*

5.51.3.1. Acoustics

5.51.3.1.1. *Methods*

Acoustics

Based on data reported to SGMED-10-02 total biomass, abundance, length and age composition for GSA 22 were estimated by acoustics from 2003 to 2008. No age distribution data were reported through the DCR for 2008. No acoustic survey took place in 2007.

Acoustic surveys methodology

Acoustic echoes were registered continuously along 70 pre-defined transects in northern Aegean Sea in June 2003, 2004, 2005, 2006 and 2008 with a Biosonics Split Beam 38 kHz DT-X echosounder. The acoustic methodology followed is described in Machias et al. (2007) (see GFCM 2007 related WD). Hydroacoustic data analysis was performed using the Sonardata Echoview software v3.30. Echo trace classification was applied based on a) echogram visual scrutinisation and direct allocation of school marks that characterise sardine as well as b) allocation on account of representative fishing stations that were held along transects (MacLennan and Simmonds, 1992).

In order to estimate sardine biomass, the length-weight- relationship is required as well as species length frequency distribution per area. Therefore, 22, 23, 27, 37 and 30 pelagic trawls were made along transects in 2003, 2004, 2005, 2006 an 2008 respectively, in the positions of high fish concentrations. A random sample of 200 specimens was obtained from each haul for further laboratory analysis. Subsequently, the length-weight- relationship was estimated from the total number of hauls according to the equation:

$$W = a\,L^b$$

where W is the total weight; L is the total length and a and b are constants that are estimated by regression analysis.

The mean length frequency was estimated in two sub-areas: (a) Eastern area (Thracian Sea and Strymonikos Gulf) and (b) Western area (Thermaikos and Evoikos Gulfs). In the two sub-areas, the mean frequency of each length class was estimated as follows:

$$f_j = \frac{\sum_{k=1}^{M}\left(\frac{n_{jk}}{t_k}\right)}{\sum_{k=1}^{M}\left(\frac{N_k}{t_k}\right)}$$

where f_j is the mean frequency of sardine of length class j; n_{jk} is the number of specimens of length class j in haul k; N_k is the total number of sardines in haul k; t_k is the duration of haul k and M is the number of hauls in the area. The above equation is appropriate even if the catches are small and the length distributions are poorly defined. It takes accounts of the haul duration, since it is supposed that on average, longer hauls will produce more fish (MacLennan and Simmonds 1992).

The density of targets (F) from the observed echo integrals were estimated according to the equation F= $(K/\langle\sigma\rangle)E$, were K is the calibration factor, $\langle\sigma\rangle$ is the mean cross-section and E is the echo integral after partitioning (MacLennan and Simmonds ,1992). The target strength (TS) – total length relationship used for sardine was: TS=20 logL-72.6, where L is fish total length (ICES 2006). The $\langle\sigma\rangle$ was calculated for the mean total fish length of each area according to the equations $\langle\sigma\rangle = 4\pi\sum_{\iota} f_i 10^{TS/10}$, where f_l is the corresponding length frequency as deduced from the fishing samples (MacLennan and Simmonds, 1992).

The abundance Q was estimated separately for the eastern and the western part of the study area. The abundance Q in each elementary statistical sampling area was calculated from the average density within each sub-area according to the equation:

$$Q = A_k \sum_i F_i / N_k ,$$

where F_i is the i sample; A_k is the area of each elementary statistical sampling area and N_k is the number of transects in A_k. The variance V was estimated as

$$V = \sum_i (AF_l - Q)^2 / [N_r(N_{r-1} - 1)]$$

The data were log transformed and the means and variances of F estimated according to the following equations:

$$F = \exp(m)\mathbf{G_N}[0.5\ S/(n-1);\ V = F^2 - \exp(2m)\ \mathbf{G_N}[S(n-2)/(n-1)^2];$$

where m = average (lnF); S= variance (lnF) and n = independent observations of F.
The total abundance Q_t and its variance were obtained by summing the results for each region $Q_t = Q_1 + Q_2 + \ldots$, and $V_t = V_1 + V_2 + \ldots$. Standard error of Q_t is the square root of V (MacLennan and Simmonds 1992).

5.51.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.51.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the sardine stock in GSA 22 was derived from the acoustics surveys. Figure 5.51.3.1.3.1 shows the estimated trend in sardine Total Biomass (estimated by acoustics) for GSA 22. Figure 5.51.3.1.3.2 shows the estimated trend in sardine abundance (estimated by acoustics).

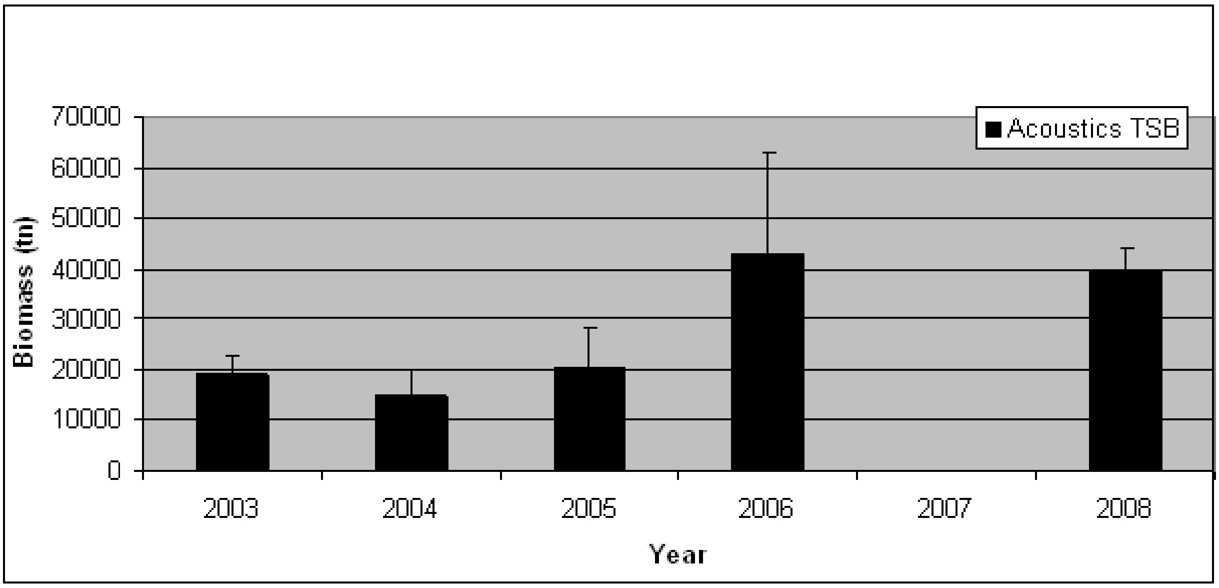


Fig. 5.51.3.1.3.1 Estimated sardine biomass indices for GSA 22, 2003-2006 and 2008.

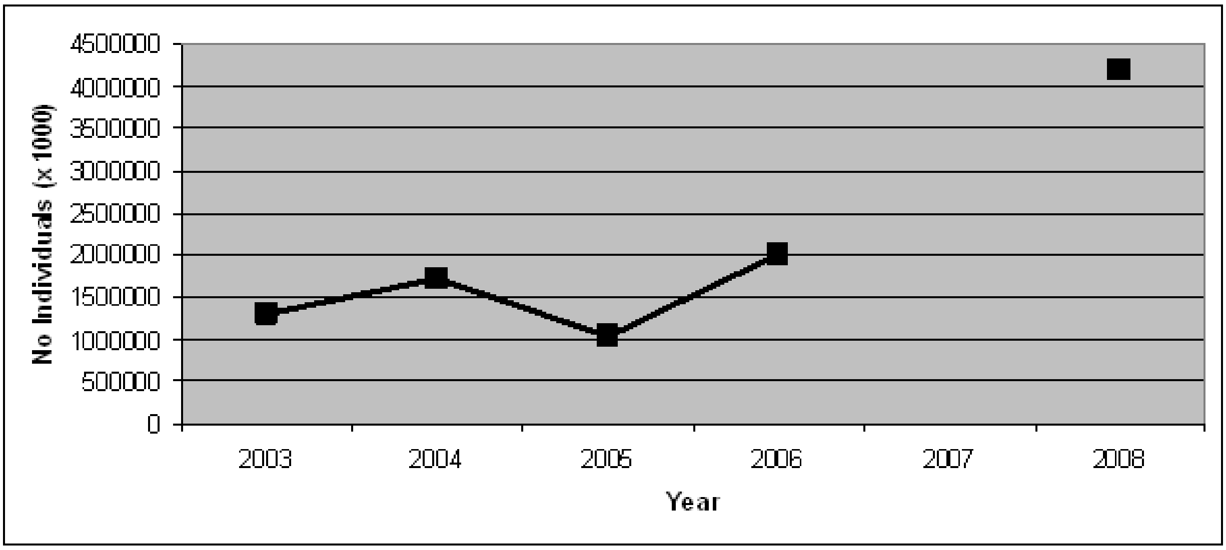


Fig. 5.51.3.1.3.2 Estimated sardine abundance indices from acoustic surveys for GSA 22, 2003-2006 and 2008.

An increasing trend was observed in both biomass and abundance indices since 2005 based on acoustic surveys estimates (Fig. 5.51.3.1.3.1, Fig. 5.51.3.1.3.2).

5.51.3.1.4. Trends in abundance by length or age

Figure 5.51.3.1.4.1 displays the length frequency composition of the sardine stock as derived from the acoustic survey for GSA 22.

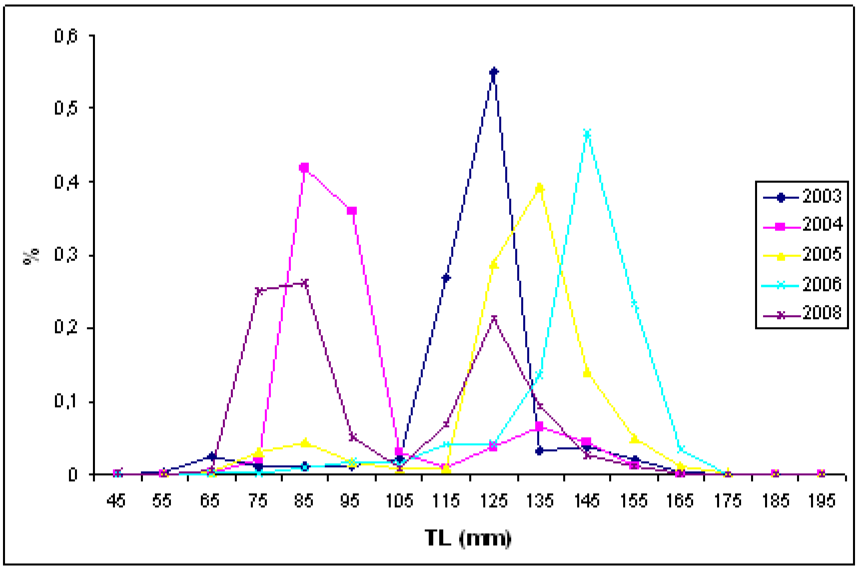


Fig. 5.51.3.1.4.1 Estimated changes in size compositions for GSA 22 for 2003-2006 and 2008.

Fig. 5.51.3.1.4.2 and Fig. 5.51.3.1.4.3 show the abundance indices by size and age of GSA 22 in 2003-2006 and 2008 as derived from acoustic surveys.

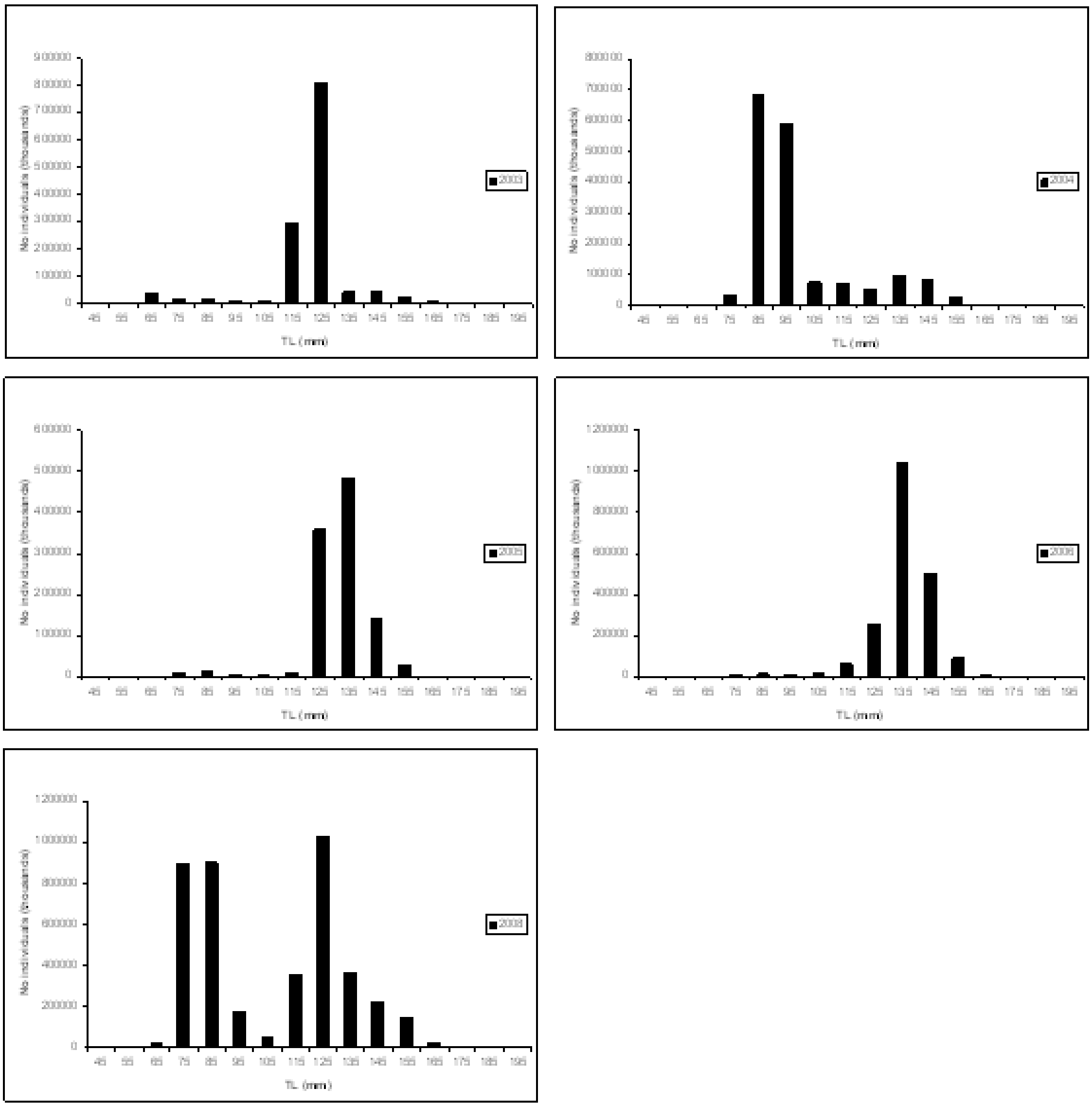


Fig. 5.51.3.1.4.2. Abundance indices by size for sardine in GSA 22 based on acoustic surveys for 2003-2006 and 2008.

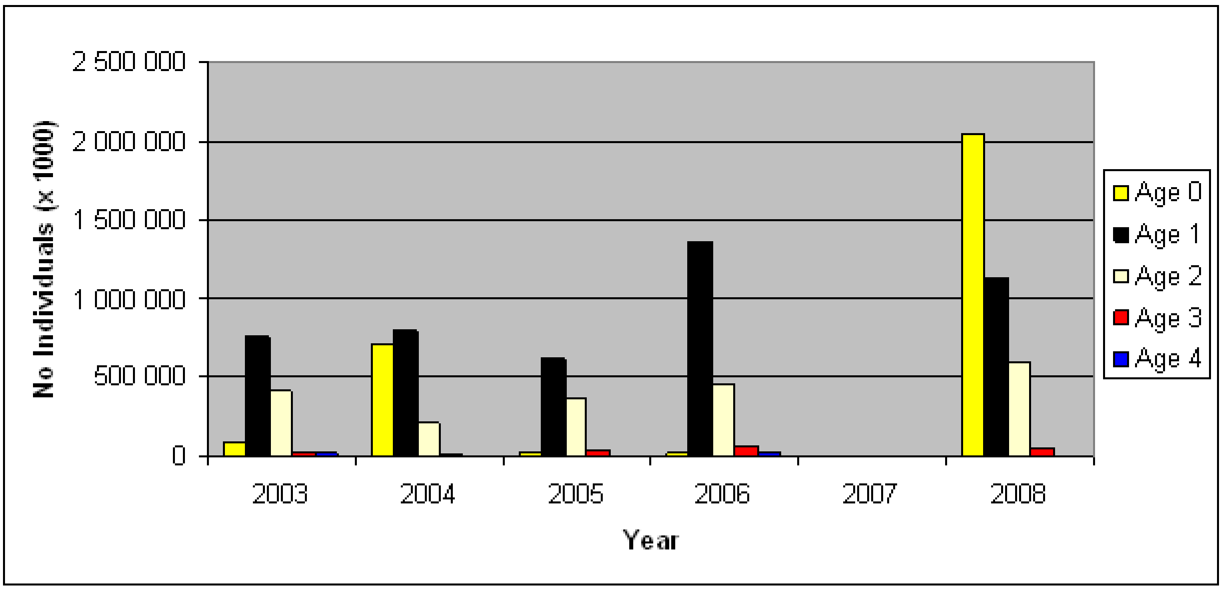


Fig. 5.51.3.1.4.3. Abundance indices by age for sardine in GSA 22 based on acoustic surveys for 2003-2006 and 2008.

5.51.3.1.5. *Trends in growth*

No analyses were conducted during SGMED-10-02. Growth equation was supplied through DCR and it was estimated based on aggregated data collected in GSA 22 for the period 2003 to 2008.

5.51.3.1.6. *Trends in maturity*

No analyses were conducted during SGMED-10-02. Maturity ogive based on biological sampling and length at first maturity estimates were used (Tab. 5.51.3.1.6.1).

Tab. 5.51.3.1.6.1. Maturity ogive for sardine in GSA 22.

Age	2003	2004	2005	2006	2007	2008
0	0	0	0	0	0	0
1	0.5	0.5	0.5	0.5	0.5	0.5
2	1	1	1	1	1	1
3	1	1	1	1	1	1
4	1	1	1	1	1	1

5.51.4. *Assessment of historic stock parameters*

5.51.4.1. Method: ICA

5.51.4.1.1. *Justification*

Integrated Catch at Age (ICA) analysis for stock assessment (Patterson and Melvin 1996; Patterson, 1998) was applied. Integrated Catch at age analysis uses separable virtual population analysis (VPA) (Pope & Shepherd, 1985) with weighted tuning indices. It was applied regarding the Aegean sardine stock during the SGMED-09-02 as an update of the one adapted in the SGMED-08-04 report (Cardinale *et al*., 2008). In addition Y/R analysis was applied during the SGMED-09-02.

5.51.4.1.2. *Input parameters*

ICA was based on commercial catch data (2000-2008) and biomass estimates from acoustic surveys over the period 2003-2006 and 2008 were used as tuning indices. Sardine data concerned annual sardine landings, annual sardine catch at age data (2000-2008), mean weights at age, maturity at age and the results of acoustic surveys presented in Table 5.51.4.1.2.1 to 5.51.4.1.2.6. Reference age for the fishery was age group 2, as fully exploited and fully recruited. Six years separability was selected. The age groups 0, 4 and 5 were underweighted in the analysis based on their percentage in the catch. Age 1 was also underweighted in the acoustic surveys (0.5). Linear catchability relationship was assumed for the acoustic surveys. Different natural mortality values were applied per age group but constant for all years based on ProBiom (Abella *et al*., 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. This method for estimating natural mortality is consistent with the methodology used in GSAs 05, 06 and 17 for small pelagics. Estimated M was considered realistic, representative of the actual situation in the area taking into account the abundance of predators in the area and the strong dependence of the juveniles of small pelagics from environmental conditions. Average values of maturity ogive and weight at age in the stock were use for 2007.

Tab. 5.51.4.1.2.1. Catch at age (numbers in thousands) of sardine stock in GSA 22 for 2000-2008.

Year	0	1	2	3	4
2000	542	167063	545713	53729	2803
2001	757	271776	593377	47206	2875
2002	2112	210186	340393	23117	1662
2003	1124	102214	257926	21728	1088
2004	1165	123086	234820	5952	1247
2005	629	122114	411857	42586	2264
2006	492	146366	356388	65384	2100
2007	2660	207030	183717	14145	1254
2008	7395	262961	228636	16988	1165

Tab. 5.51.4.1.2.2. Catches estimates (in t) of sardine stock in GSA 22 for 2000-2008.

Year	Sardine
2000	18075
2001	19115
2002	11483
2003	8260
2004	8660
2005	14444
2006	12984
2007	9064
2008	9700

Tab. 5.51.4.1.2.3. Weight at age in the catch of sardine stock (in kg) in GSA 22 for 2000-2008.

	Year								
Age	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	.0064	.0081	.0103	.0071	.0068	.0005	.0095	.0086	.0063
1	.0206	.0191	.0185	.0190	.0210	.0220	.0214	.0216	.0185
2	.0247	.0200	.0198	.0215	.0235	.0260	.0231	.0236	.0201
3	.0241	.0240	.0218	.0250	.0249	.0265	.0252	.0246	.0212
4	.0441	.0650	.0516	.0516	.0516	.0516	.0415	.0498	.0469

Tab. 5.51.4.1.2.4. Weight at age in the stock (in kg) of sardine stock in GSA 22 for 2000-2008.

	Year								
Age	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	.0036	.0036	.0036	.0029	.0044	.0037	.0037	.0036	.0035
1	.0152	.0152	.0152	.0152	.0073	.0183	.0203	.0171	.0141
2	.0201	.0201	.0201	.0162	.0225	.0225	.0239	.0198	.0163
3	.0237	.0237	.0237	.0169	.0317	.0223	.0296	.0235	.0180
4	.0383	.0383	.0383	.0206	.0516	.0516	.0298	.0339	.0378

Tab. 5.51.4.1.2.5. Maturity ogive of sardine stock in GSA 22 for 2003-2008.

Year	0	1	2	3	4
2003	0	.5	1	1	1
2004	0	.5	1	1	1
2005	0	.5	1	1	1
2006	0	.5	1	1	1
2007	0	.5	1	1	1
2008	0	.5	1	1	1

Tab. 5.51.4.1.2.6. Age-structure indices of sardine (numbers in thousands) stock in GSA 22 for 2003-2006 and 2008. Age 3 was considered a plus age group.

Age	2003	2004	2005	2006	2007	2008
1	752287	790094	622031	1398063	-1	1213128
2	422307	208857	363658	487685	-1	871381
3+	39859	7771	35816	87914	-1	54074

5.51.4.1.3. Results including sensitivity analyses

The graphical diagnostics of the model shown in Figs. 5.51.4.1.3.1 to 5.51.4.1.3.4 generally showed good model fit besides the acoustic surveys index at age 3 in years 2006 and 2008. Residual plots for recent years showed no strong deviations from separability. SSQ plot (Fig. 5.51.4.1.3.5) possibly indicated some degree of inconsistency between the model and the indices (minima not fairly close to each other on x-axis, Needle (2000)).

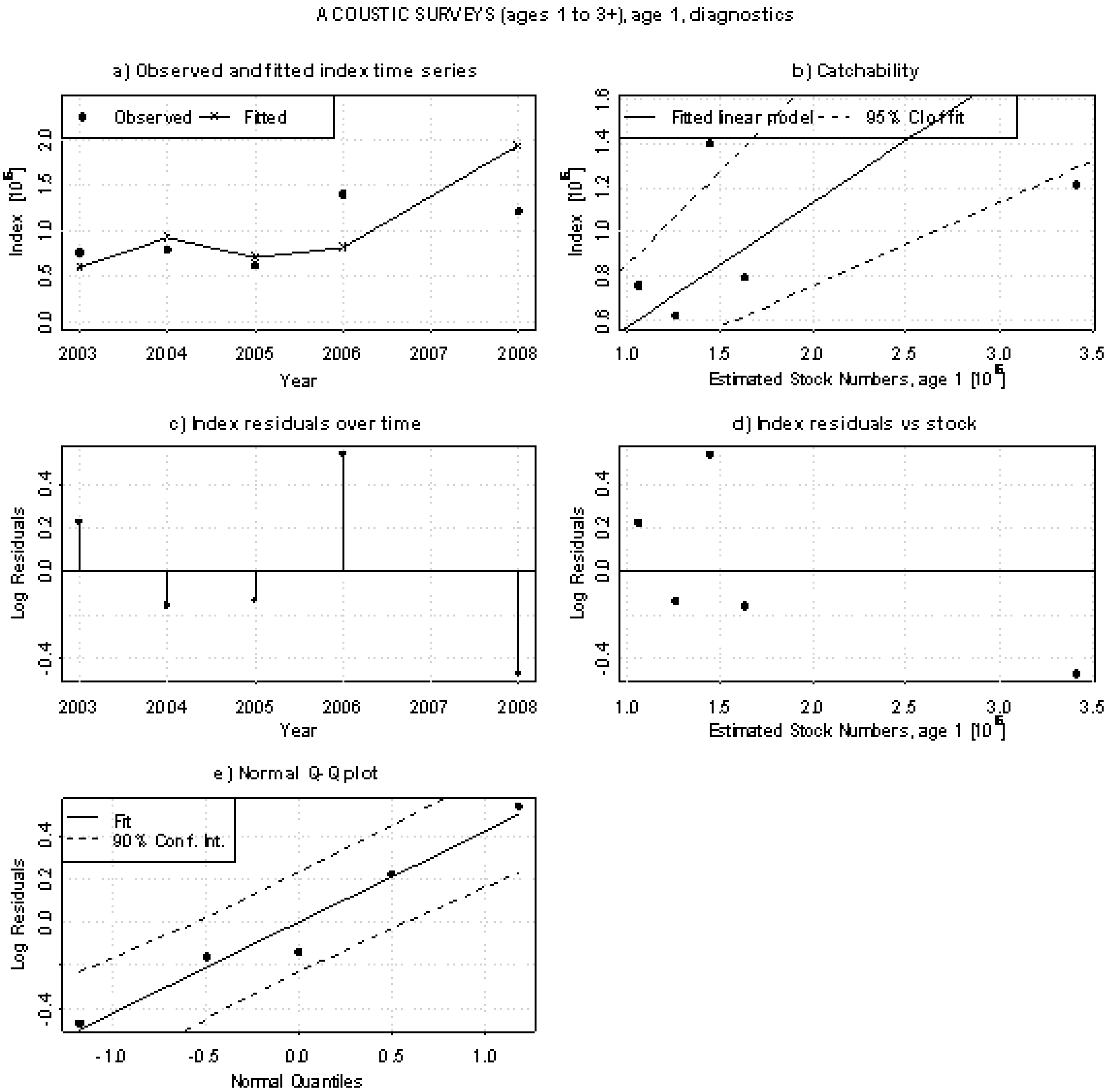


Fig. 5.51.4.1.3.1 Residual plots for age 1 indices of sardine ICA model for GSA 22 (2003-2008).

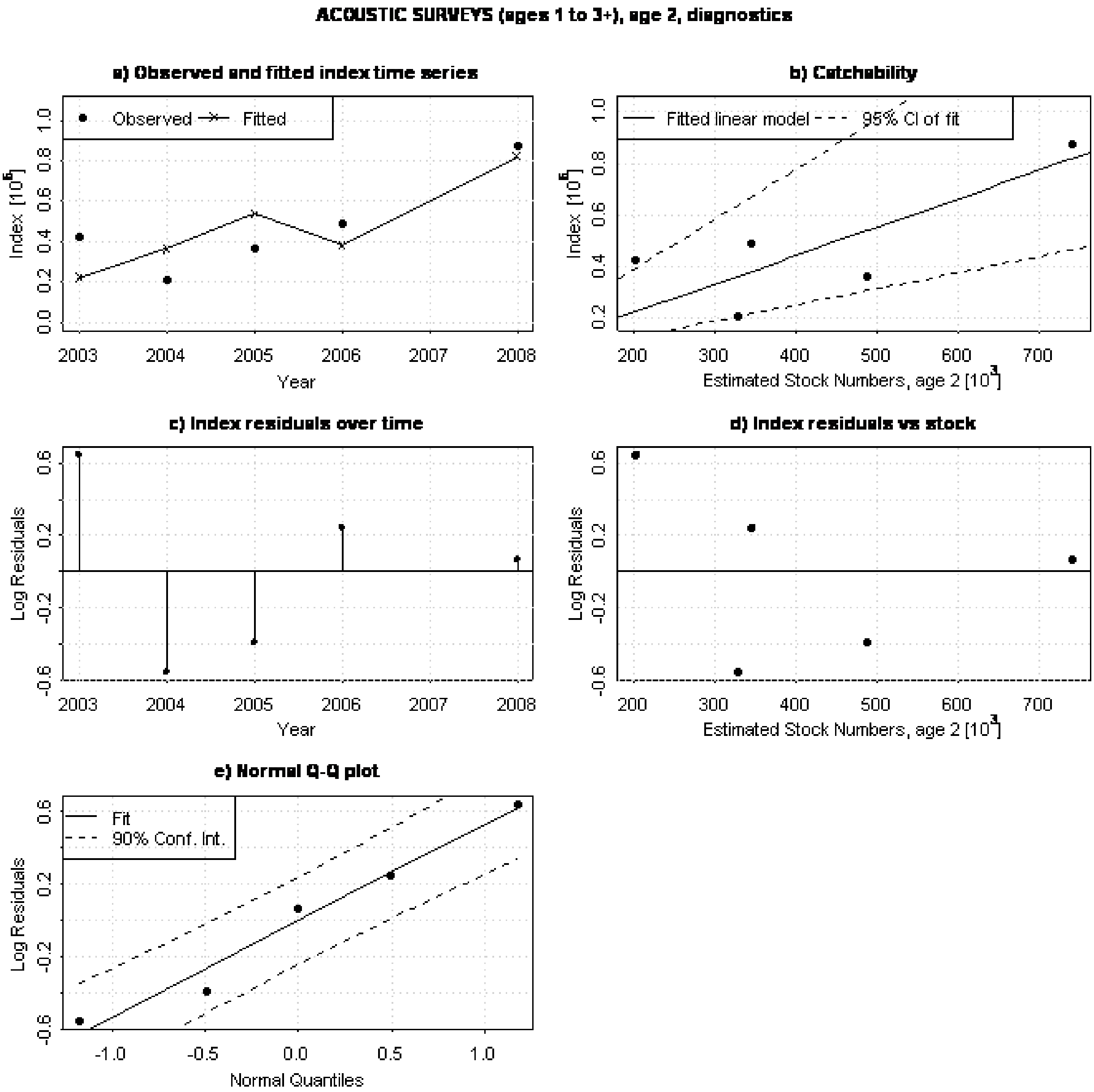


Fig. 5.51.4.1.3.2 Residual plots for age 2 indices of sardine ICA model for GSA 22 (2003-2008).

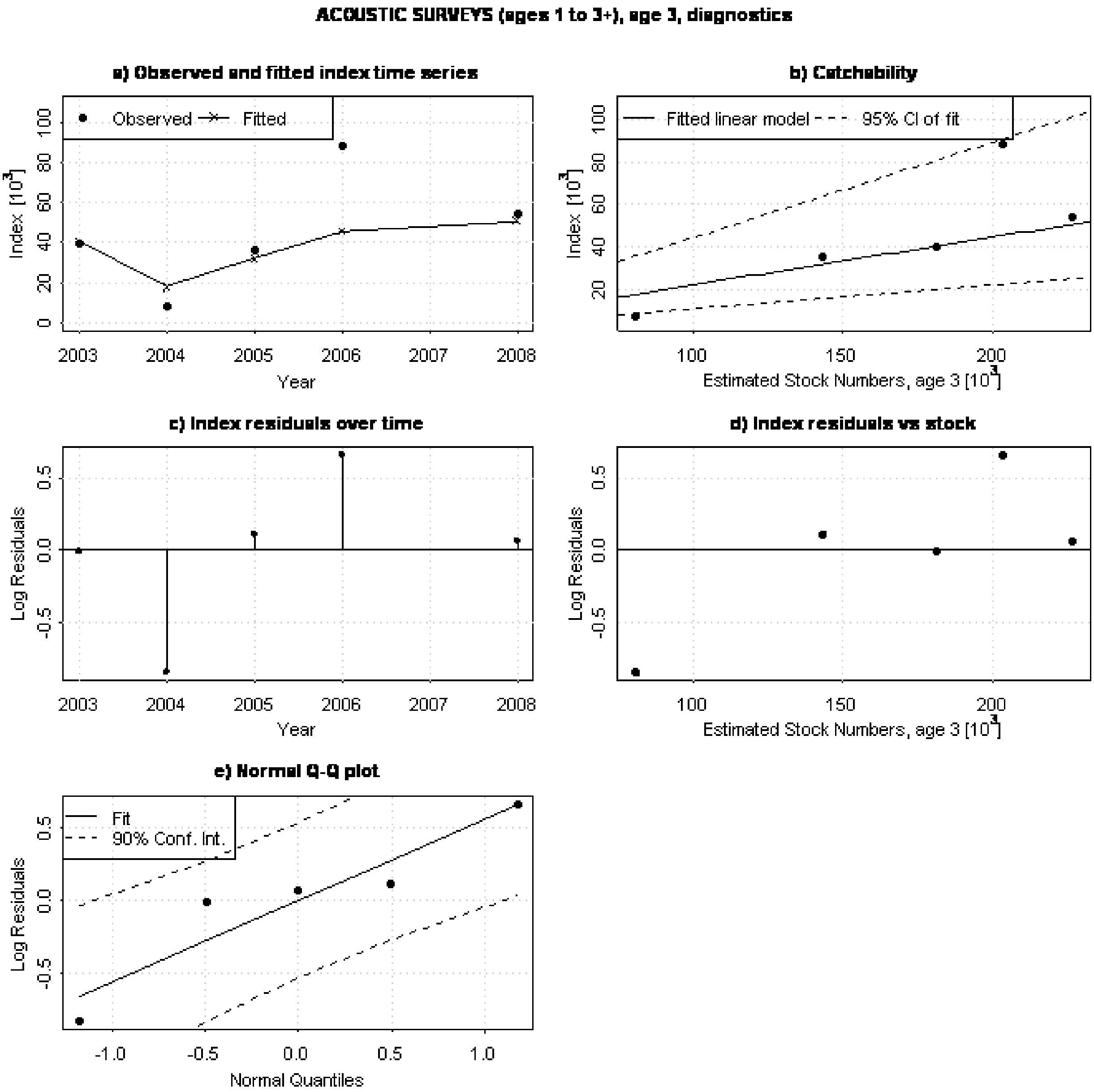


Fig. 5.51.4.1.3.3 Residual plots for age 3 indices of sardine ICA model for GSA 22 (2003-2008).

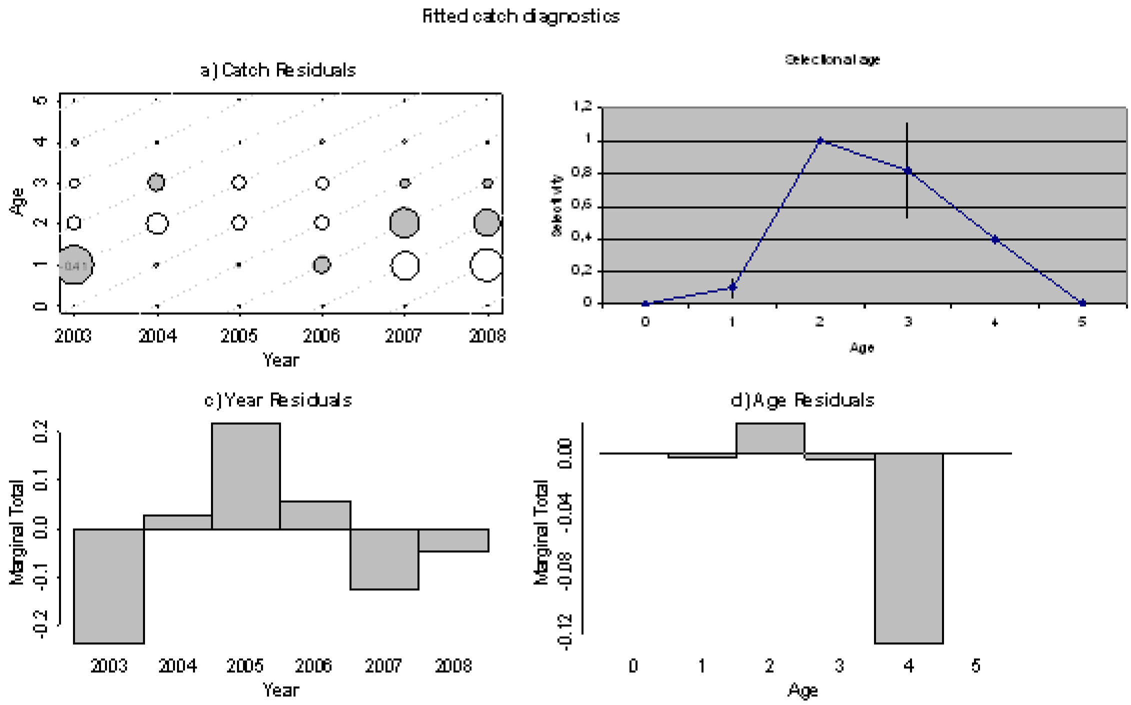


Fig. 5.51.4.1.3.4 The catch at age residuals Residual plots for catch of sardine ICA model for GSA 22 (2003-2008).

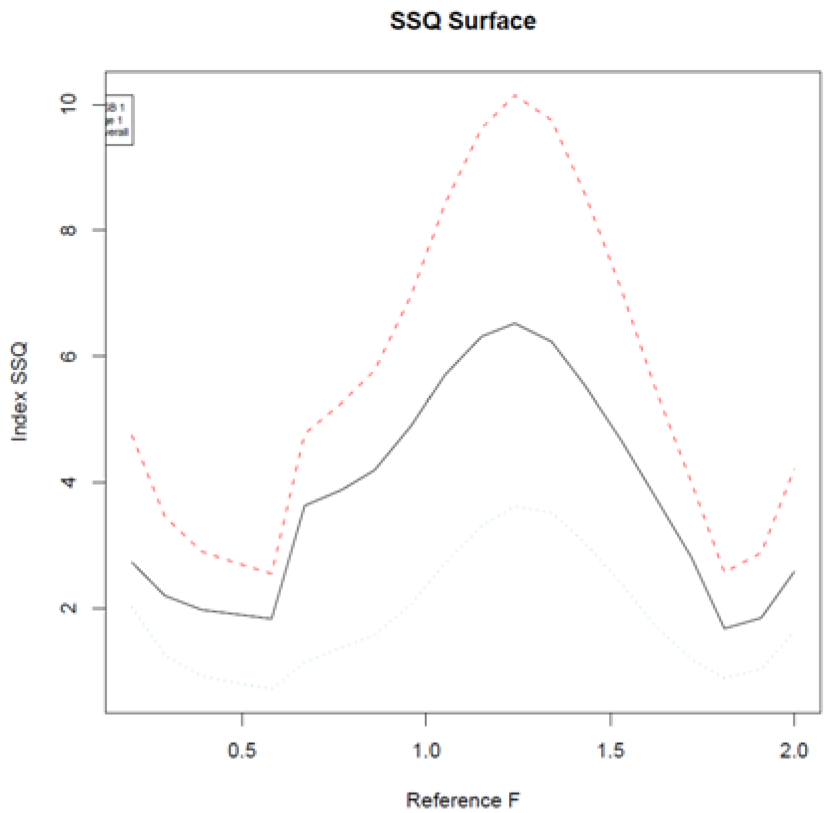


Fig. 5.51.4.1.3.5 Sum of Squares (SSQ) surface plot of the Anchovy ICA Model.

ICA model results for sardine stock in GSA 22 are shown in Fig. 5.51.4.1.3.6, indicating an increasing trend for recruitment in 2008. However this is probably an overestimation of the last year as the model predicts a decrease at the level of 2006 for 2009. An increase in biomass has also been observed since 2004. F mean (ages 1to 3) shows a decrease since 2006. The landings to Total Biomass ratio decreases, approximating on average 2% in 2008 based on model results. Similarly, the landings to SSB ratio decreases approximating on average 40% based on model results.

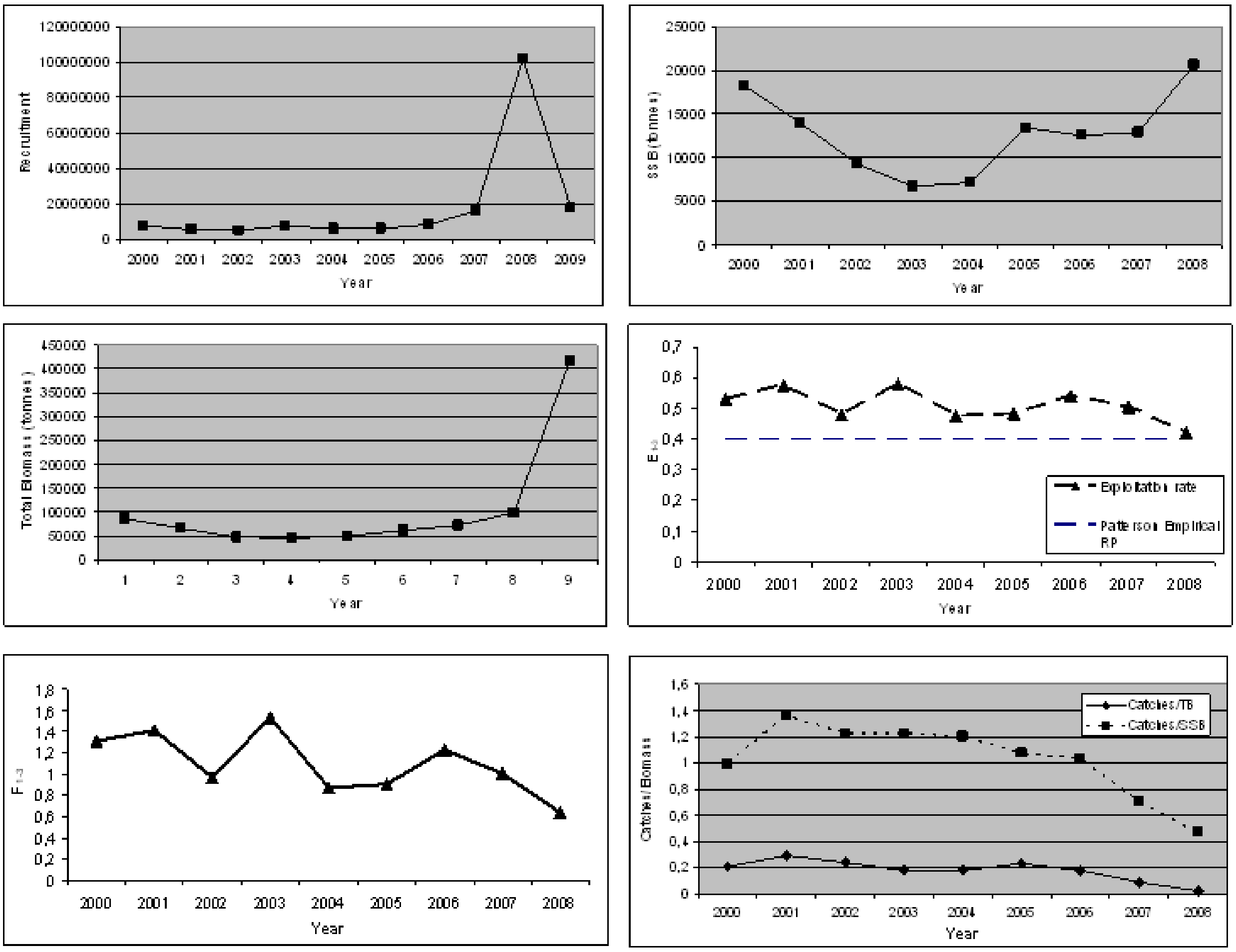


Fig. 5.51.4.1.3.6 Sardine ICA Model results: Recruitment, SSB, Total biomass, exploitation rate (F/Z), Fmean for ages 1-3, landings to biomass ratio.

Retrospective analysis was applied in the ICA model for the Aegean sardine 2000-2008 with one year backward analysis. Applying the analysis with more than one year backward was not possible due to the short time series available. Results are presented in Fig. 5.51.4.1.3.7., showing no particular retrospective bias.

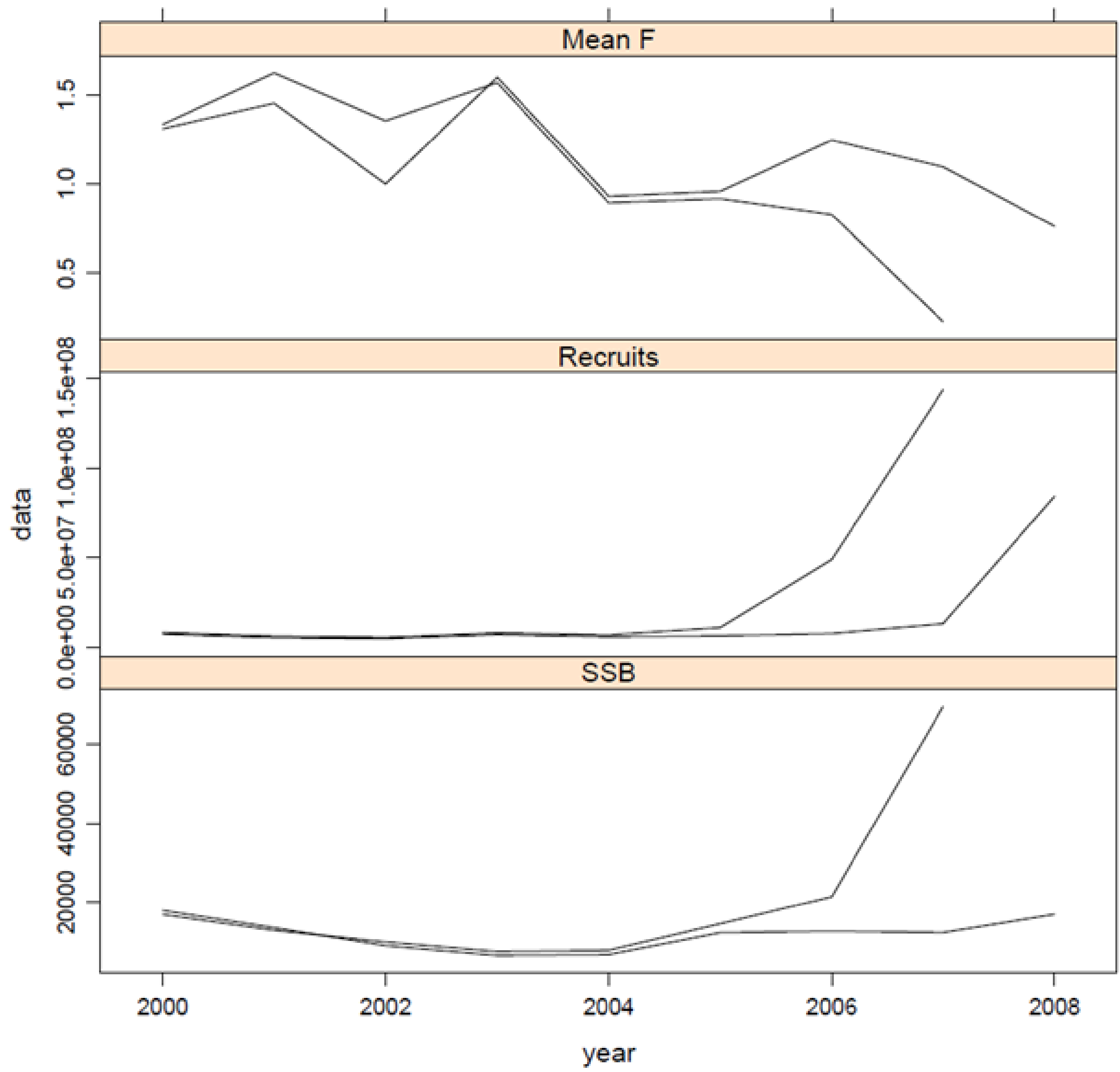


Fig. 5.51.4.1.3.7. The results of retrospective analysis in the Aegean Sea sardine ICA model 2000-2008, concerning F mean 1-3, SSB and recruitment.

5.51.5. Long term prediction

5.51.5.1. Justification

Yield per recruit analysis was conducted in the SGMED-10-02 assuming equilibrium conditions.

5.51.5.2. Input parameters

Yield per recruit analyses was conducted based based on the exploitation pattern resulting from the ICA model and population parameters, Minimum and maximum age for the analysis were considered to be age group 0 and 4, respectively. Stock weight at age, catch weight at age and maturity ogive were estimated as mean values on a long term basis (2000-2008). Natural mortality was considered different per age group based on ProBiom estimations. Fishing mortalities were estimated in a short term basis (2004-2008). Reference F was considered to be mean F for ages 1 to 3. Input parameters are shown in Table 5.51.5.2.1.

Tab. 5.51.5.2.1. Input parameters for Y/R analysis.

age group	stock weight	catch weight	maturity	F	M
0	0.004	0.007	0	0.0003	1.50
1	0.015	0.020	0.5	0.1804	0.96
2	0.020	0.022	1	1.7100	0.69
3	0.024	0.024	1	1.3951	0.61
4	0.038	0.050	1	0.7055	0.57

5.51.5.3. Results

Y/R analyses were performed (Fig. 5.51.5.3.1) but were not considered reliable due to its flat-topped shape. Therefore,$F_{0.1}$ (1.20) cannot be used as a reference point for this stock.

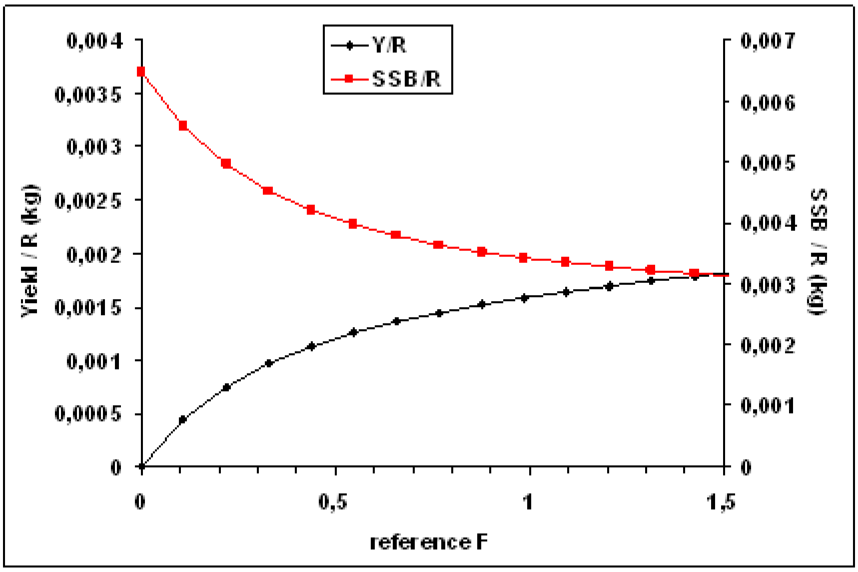


Fig. 5.51.5.3.1. Yield per recruit for the sardine stock in GSA 22.

5.51.6. Scientific advice

5.51.6.1. Short term considerations

5.51.6.1.1. State of the spawning stock size

The results of the short time series of data do not allow to conclude on reference points of B_{lim} or B_{pa}. In the absence of proposed or agreed precautionary management reference points, SGMED-10-02 is unable to fully evaluate the state of the stock and provide scientific advice.

Recent estimates of fishery independent surveys for sardine in GSA 22 indicated an increase of total biomass estimates when compared to the earlier years 2003-2005 (42,850 t in 2006 and 39,000 t in 2008 estimated by acoustics). Similarly, results of the Integrated Catch at Age analysis indicated an increasing trend in total biomass and SSB showing a slight recovery of SSB to 20,000 t in 2008 from the low 2003-2004 estimates of 7,000 t.

5.51.6.1.2. State of recruitment

ICA model estimates showed above average recruitment since 2007, with a very high peak in 2008.

5.51.6.1.3. State of exploitation

SGMED-10-04 proposes E=0.4 as limit management reference point consistent with high long term yields.

Based on ICA results, the mean fishing mortality (averaged over ages 1 to 3) is highly variable but showed a clear decreasing trend since 2006, amounting approximating 0.64 in 2008.

The mean F/Z has declined from 2003 reaching the value of 0.41 which approximates the exploitation reference points (E<0.4, Patterson 1992) suggested by SGMED for small pelagics. Taking into account the uncertainty in the estimate, SGMED-10-02 considers the stock as being harvested sustainably. The exploitation rate should be kept at this level through constant effort and consistent catches should be determined. The management of the sardine fishery requires mixed fisheries implications to be considered, mainly with anchovy.

5.52. Stock assessment of sole in GSA 17

5.52.1. Stock identification and biological features

5.52.1.1. Stock Identification

Tagging experiments carried out on common sole in the northern Adriatic Sea, using the traditional mark-and-recapture procedure, showed that all individuals were re-captured within the sub-basin (Pagotto *et al.*, 1979). Local currents, eddies and marked differences of oceanographic features of this sub-basin with respect to those of southern Adriatic and Ionian Sea (Artegiani *et al.*, 1997) may prevent a high rate of exchange of adult spawners and the mixing of planktonic larval stages from nursery areas of adjacent basins (Magoulas *et al.*, 1996). Guarniero *et al.* (2002), taking into account differences of sole specimens from five different central Mediterranean areas in the control region sequence marker, suggested that two near-panmictic populations of common sole could exist in the Adriatic Sea. The former population would inhabit the entire GSA 17 (northern Adriatic Sea). The second unit seems to be spread along the Albanian coasts (eastern part of the GSA 18). The hydrogeographical features of this semi-enclosed basin might support the overall pattern of differentiation of the Adriatic common soles.

The northern Adriatic Sea has a high geographical homogeneity, with a wide continental shelf and eutrophic shallow-waters. The southern Adriatic in contrast is characterized by narrow continental shelves and a marked, steep continental slope (1200 m deep; Adriamed, 2000). This deep canyon could represent a significant geographical barrier for *S. solea*.

On these bases, different actions for fishery management should be proposed for the Adriatic common sole stocks in GSA 17 and GSA 18. In the former area the stock is shared among Italy, Slovenia and Croatia, while in the latter one seems to be shared only between Montenegro and Albania.

S. solea is a demersal and sedentary species, living on sandy and muddy bottoms (Tortonese, 1975, Fisher *et al.*, 1987, Jardas, 1996). Although Jardas, (1996) stated that the species is distributed from coastal waters to 250 m depth, it was exclusively caught up to 100 m during the expedition MEDITS (1996-1998) (Vrgoč, 2000).

Common sole usually feeds very often on small quantities of prey (Sà *et al.*, 2003). This suggests a high evacuation rate between the stomach and the intestine, and lack of digestion in the stomach (Lagardère, 1987). The fish feeds night and day and for the remaining time usually lives embedded in the seabed. In the Adriatic Sea food items mostly include invertebrates and small fish (Tortonese, 1975; Fisher *et al.*, 1987; Jardas, 1996). Within the framework of SoleMon project, a study of gut content using carbon- and nitrogen stable isotopes along the sole food web was carried out, indicating that *S. solea* diet depends on both the geographical position and the size of soles, which change their feeding habit with the increase of the age. This could be related to the fact that the sole selects its preys basing on both their energetic value and the energy spent to catch them. The choice of sole would be also related to prey abundance, as postulated by the "*optimal foraging theory*" (MacArthur and Pianka, 1966) and observed in other flatfish (Hinz *et al.*, 2005). Stergiou and Karpouzi (2002) found that in the Mediterranean Sea the sole increases its trophic level with the increasing of the size, reaching values around 3.4. The mean trophic level estimated from the SoleMon project data through the stable isotope analysis was slightly higher (3.9), but similar to the value obtained in a study carried out in the Rodano mouth (Darnaude, 2005).

5.52.1.2. Growth

In the Adriatic sea, growth analyses on this species have been made using otoliths, scales and tagging experiments. A great variability in the growth rate was noted: some specimens had grown 2 cm in one month, while others, of the same age group, needed a whole year (Piccinetti and Giovanardi, 1984; Tab. 5.52.1.2.1). Von Bertalanffy growth equation parameters have been calculated using various methods.

Within the framework of SoleMon project, growth parameters of sole were estimated through the length-frequenzy distributions obtained from surveys (Fig. 5.52.1.2.1; Tab. 5.52.1.2.2).

Tab. 5.52.1.2.1. Growth rates of *S. solea* from different studies. (TL, cm; age, yr).

Author	**Sex**	**Age**					
		1	**2**	**3**	**4**	**5**	**6**
Ghirardelli (1959)	M+F	16.8	21.4	23.9	25.6	33.1	-
Piccinetti and Giovanardi (1984)	M+F	18-20	21-30	-	-	-	-
Vallisneri *et al.* (2000)	F	20	25	29	32	34	37

Tab. 5.52.1.2.2. Von Bertalanffy parameters of *S. solea* estimated in different studies. *(k, yr^{--1}; t_0, yr).

Author	**Sex**	**W_8(g)**	**L_8 (cm)**	**k ($month^{-1}$)**	**t_0 (month)**
Piccinetti and Giovanardi (1984)	M+F	-	40.10	0.68*	-
Froglia and Giannetti (1985)	M+F	-	38.25	0.041	-3.57
Froglia and Giannetti (1986)	M	323	23.20	0.069	-1.66
	F	562	37.87	0.042	-5.36
	M+F	576	38.25	0.041	-3.57
Fabi *et al.* (2009)	M+F	-	39.60	0.44*	-0.46*

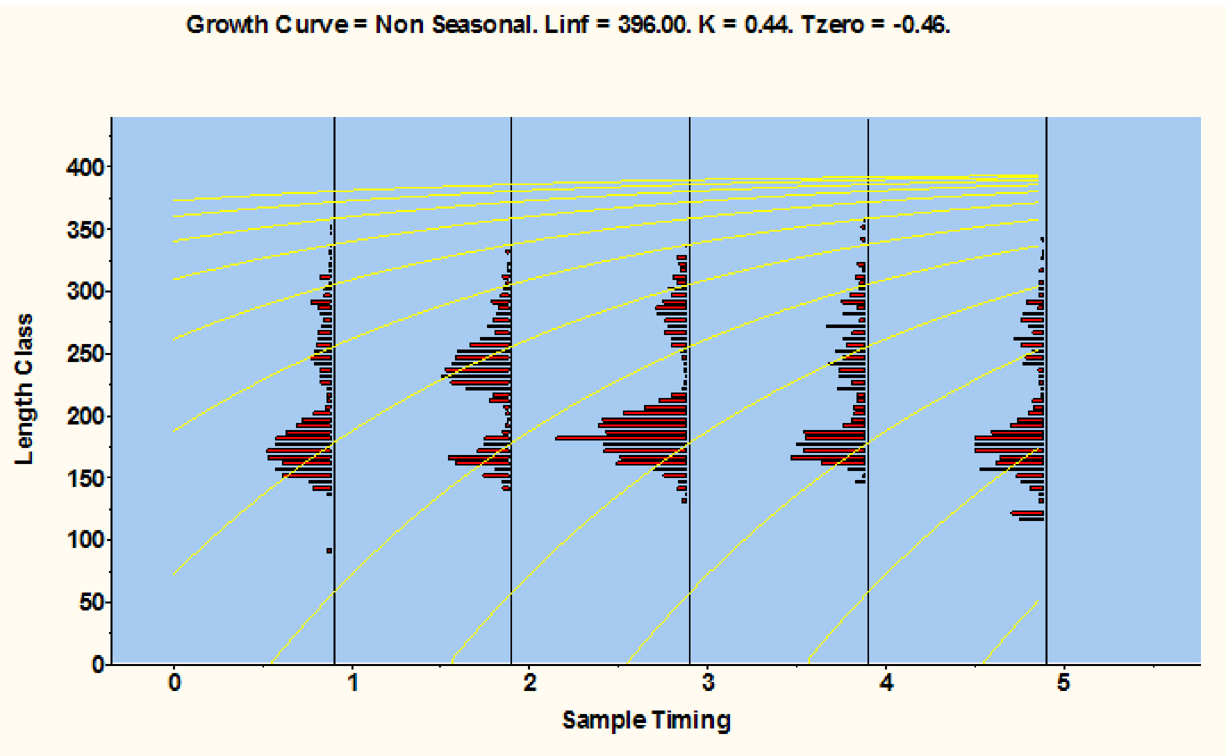


Fig. 5.52.1.2.1 Von Bertalanffy growth functions for sole in the GSA 17, based on SoleMon length frequency distributions (2005-2009).

5.52.1.3. Maturity

In the Mediterranean Sea, the reproduction of common sole occurs from December to May (Bini (1968-70), Tortonese, 1975, Fisher *et al.*, 1987). Within the framework of SoleMon project, it has been observed that in the central and northern Adriatic Sea the reproduction takes place from November to March. Data on the spatial distribution of spawners provided by the project show a higher concentration of reproducers outside the western coast of Istria (Fabi *et al.*, 2009).

Length at first maturity is 25 cm (Fisher *et al.*, 1987; Jardas, 1996; Vallisneri *et al.*, 2000); this value has been estimated at 25.8 using data from SoleMon project. Females having a weight of 300 g have about 150000 eggs, while those weighting 400 g have about 250000 eggs (Piccinetti and Giovanardi, 1984); eggs are pelagic. The male-female ratio is approximately 1:1 (Piccinetti and Giovanardi, 1984; Fabi *et al.*, 2009). Hatching occurs after eight days and the larva measures 3 to 4 mm TL (Tortonese, 1975). Eye migration starts at 7 mm TL and ends at 10-11 mm TL. Benthic life begins after seven or eight weeks (15 mm) in coastal and brackish waters (Bini (1968-70); Fabi *et al*., 2009).

5.52.2. Fisheries

5.52.2.1. General description of fisheries

The common sole is a very important commercial species in the central and northern Adriatic Sea (Ghirardelli, 1959; Piccinetti, 1967; Jardas, 1996; Vallisneri *et al.*, 2000; Fabi *et al.*, 2009). Italian *rapido* trawlers exploit this resource providing more than 80% of landings. Sole is also a target species of the Italian and Croatian set netters, while it represents an accessory species for otter trawlers.

From censuses carried out at the landing sites, the Italian rapido trawl fleet operating in GSA 17 was made of 155 vessels in 2005 and 124 vessels in 2006 ranging from 9 to 30 m in vessel length, GRT ranged from 4 to 100 and the engine power from 60 to 1000 HP. Each vessel can tow from 2 to 4 rapido trawls depending on its dimensions. The *rapido* trawl is a gear used specifically for catching flatfish and other benthic species (e.g. cuttlefish, mantis shrimp, etc.). It resembles a toothed beam-trawl and is made of an iron frame provided with 3-5 skids and a toothed bar on its lower side. These gears are usually towed at a greater speed (up to 10-13 km h^{-1}) in comparison to the otter trawl nets; this is the reason of the name "*rapido*", the Italian word for "fast". The mesh opening of the codend used by the Italian *rapido* trawlers is larger (48 mm stretched or more) than the legal one. The main Italian *rapido* trawl fleets of GSA 17 are sited in the following harbours: Ancona, Rimini and Chioggia.

The Italian artisanal fleet in GSA 17, according to SoleMon project data (end of 2006), accounted for 469 vessels widespread in many harbours along the coast. They use gill net or trammel net especially from spring to fall and target small and medium sized sole (usually smaller than 25 cm TL).

5.52.2.2. Management regulations applicable in 2009 and 2010

- Fishing closure for trawling: 30 days in summer.
- Minimum landing sizes: EC regulation 1967/2006: 20 cm TL for sole.
- Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets will be replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

5.52.2.3. Catches

5.52.2.3.1. Landings

In the last five years the total landings of sole of GSA 17 fluctuated between 1,673 to about 2,184 tons and although the time series is short, the general shape suggests a stable trend (Fig. 5.52.2.3.1.1).

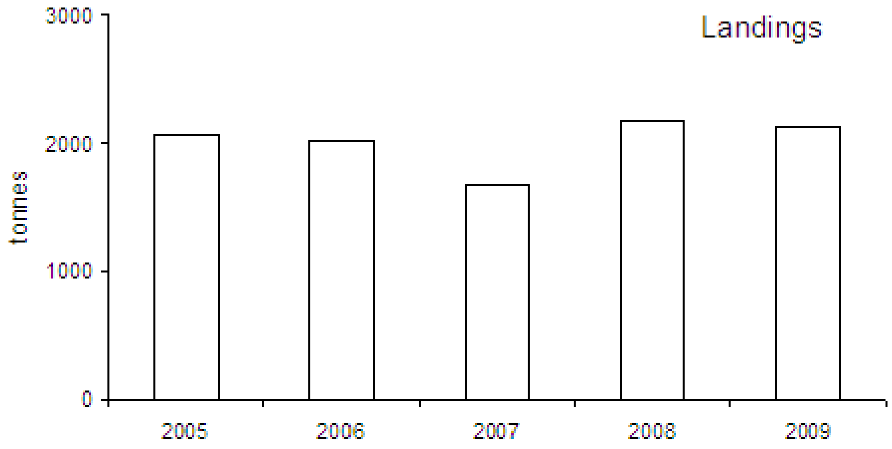


Fig. 5.52.2.3.1.1 Landings of sole (all gears) in the GSA 17, from 2005 to 2009.

Rapido trawl landings were traditionally dominated by small sized specimens; they are basically composed by 1 and 2 year old individuals. Set net fishery lands mostly the same portion of the population, while the otter trawl fishery, exploiting wider fishing grounds, shows a different size distribution of the landings (Fig. 5.52.2.3.1.2).

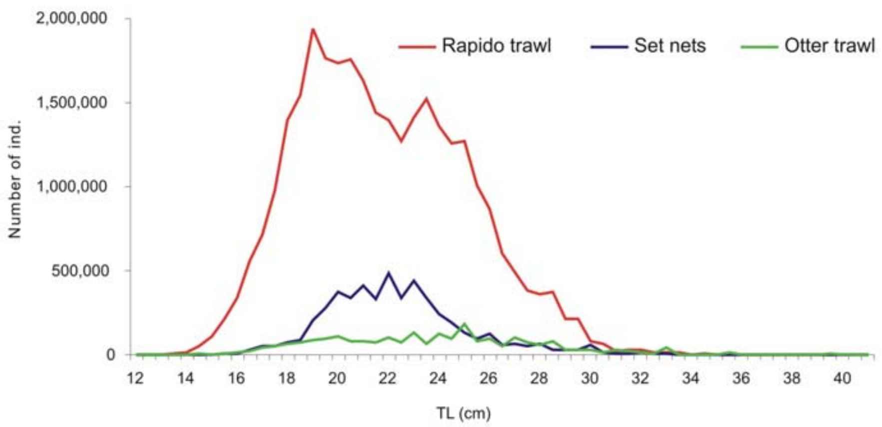


Fig. 5.52.2.3.1.2 Size structure of the landings of common sole provided in 2005-2006 by *rapido* trawl, otter trawl and set nets in the GSA 17 (SoleMon project data).

Tab. 5.52.2.3.1.1 Landings (t) 2004-2008 as reported through the official DCF data call. No data for 2009 were reported by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
SOL	17	ITA						31	21	10	0	0	
SOL	17	ITA	FPO	DEMSP				4	3	0	53	0	
SOL	17	ITA	FYK	CATSP				0					
SOL	17	ITA	FYK	DEMSP				1	0	0		0	
SOL	17	ITA	GNS	DEMSP				330	614	717	466	410	
SOL	17	ITA	GNS	SLPF								0	
SOL	17	ITA	GTR	DEMSP				133	86	52	54	44	
SOL	17	ITA	LLS	DEMF						0			
SOL	17	ITA	OTB	DEMSP				411	522	243	221	199	
SOL	17	ITA	OTB	MDDWSP				42	37	5	6	0	
SOL	17	ITA	OTM	MDPSP						0			
SOL	17	ITA	PS	LPF					0				
SOL	17	ITA	PS	SPF				0	5				
SOL	17	ITA	PTM	SPF				0	0		1		
SOL	17	ITA	TBB	DEMSP				399	373	863	692	576	
SOL	17	SVN	FPO	DEMSP	NA					0	0		
SOL	17	SVN	FYK	DEMSP	NA				0				
SOL	17	SVN	GND	SPF	20D40					0		0	
SOL	17	SVN	GNS	DEMSP	16D20				2	3	4	3	2
SOL	17	SVN	GTR	DEMSP	50D100				10	8	13	11	18
SOL	17	SVN	LHP-LHM	FINF	NA								0
SOL	17	SVN	LLS	DEMSP	NA					0			
SOL	17	SVN	OTB	DEMSP	40D50				0	1	0	1	1
Sum								1351	1673	1902	1510	1244	21

5.52.2.3.2. Discards

Several projects carried out in a portion of GSA17 highlighted that the discard of sole both by *rapido* trawl and set net fisheries is negligible (Fabi *et al*., 2002; Fabi & Sartor, 2002) as the damaged specimens are also commercialized, even though at a lower price.

5.52.2.3.3. Fishing effort

Exploitation is based on young age classes, mainly 1 and 2 year old individuals, with immature fraction dominating the landings. From SoleMon project data, the overall Italian fleet exploiting sole in the GSA 17 is made up by around 1,300 vessels (rapido trawlers, set netters, otter trawlers; Tab. 5.52.2.3.3.1)

Tab. 5.52.2.3.3.1 Number of vessels x day exploiting sole in GSA 17 (SoleMon project data).

Year	**2005**	**2006**	**2007**	**2008**	**2009**
Effort (vessels x days)	152,182	122,669	108,830	116,860	134,430

The trends of the fishing effort of Ancona and Rimini *rapido* trawl fleets have been analyzed over the years 1996-2008 and 2005-2008 respectively. The fishing effort of Ancona fleet increased from 1996 to 2003 and declined in the subsequent years. A similar decreasing pattern also occurred for the Rimini fleet in the last four years (Fig. 5.52.2.3.3.1).

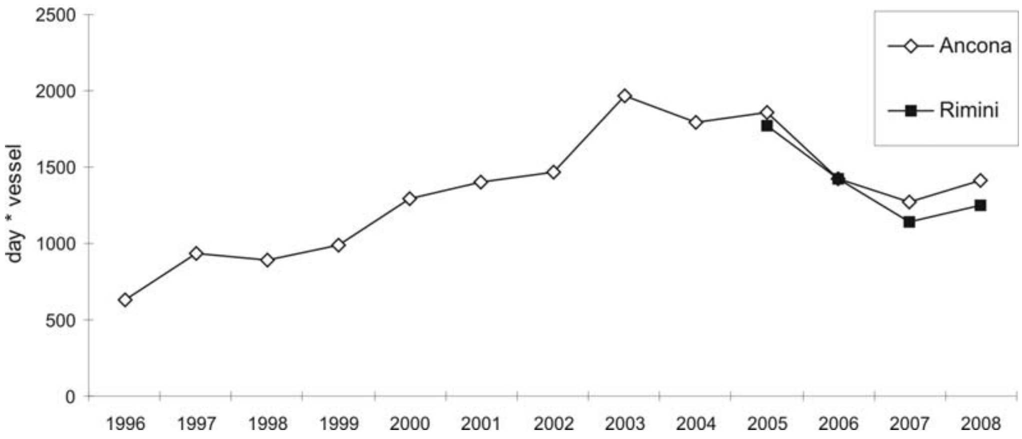


Fig. 5.52.2.3.3.1 Trends of effort (day*vessel) by Ancona and Rimini rapido trawl fleets.

Fig. 5.52.2.3.3.2 Fishing effort kW*days as reported though the official DCF data call. No data for 2009 were reported by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	SSEL_LENG	2003	2004	2005	2006	2007	2008	2009
17	ITA				VL0006				28839	19464	25018	
17	ITA				VL0612		585226	426770	538249	418073	245003	
17	ITA				VL1218		21467	23352				
17	ITA				VL2440			4097		7903		
17	ITA	DRB	MOL		VL0612		19073					
17	ITA	DRB	MOL		VL1218		581702	484258	407953	612211	492480	
17	ITA	FPO	DEMSP		VL0006				130			
17	ITA	FPO	DEMSP		VL0612		19874	17355	9999	9718	18643	
17	ITA	FYK	DEMSP		VL0006				0	0	0	
17	ITA	FYK	DEMSP		VL0612		6671	333	5572	34133	14013	
17	ITA	GND	SPF		VL0612			214				
17	ITA	GNS	DEMSP		VL0006				27244	4459	16709	
17	ITA	GNS	DEMSP		VL0612		113579	97152	43173	36087	33960	
17	ITA	GNS	DEMSP		VL1218		24644	15559	7559			
17	ITA	GTR	DEMSP		VL0006				0	0		
17	ITA	GTR	DEMSP		VL0612		14415	25334	31121	34778	26522	
17	ITA	GTR	DEMSP		VL1218			7215				
17	ITA	LLD	LPF		VL0612		7472	2384			5843	
17	ITA	LLD	LPF		VL1218		961	9928	6181	3765	416	
17	ITA	LLS	DEMF		VL0612				529	498		
17	ITA	OTB	DEMSP		VL0612		143723	70376	46397	71355	67595	
17	ITA	OTB	DEMSP		VL1218		910397	713888	599979	686576	595477	
17	ITA	OTB	DEMSP		VL1824		822314	379538	639196	779138	713636	
17	ITA	OTB	DEMSP		VL2440		479467	305876	303593	249435	249021	
17	ITA	OTB	MDDWSP		VL1824			455880				
17	ITA	OTB	MDDWSP		VL2440			101556	85117	81784	15108	
17	ITA	OTM	MDPSP		VL0612			666				
17	ITA	OTM	MDPSP		VL2440				963			
17	ITA	PS	SPF		VL0612		15395	11368				
17	ITA	PS	SPF		VL1218		1912	7297	13939	3958	1374	
17	ITA	PS	SPF		VL2440					15557		
17	ITA	PTM	SPF		VL1218		9255	28121	1056		11264	
17	ITA	PTM	SPF		VL1824		446896	309738	331008	393874	93255	
17	ITA	PTM	SPF		VL2440		170745	183571	198308	225578	385407	
17	ITA	TBB	DEMSP		VL1218		32478	16587	30023	74266	54618	
17	ITA	TBB	DEMSP		VL1824		229009	266268	365432	304104	172961	
17	ITA	TBB	DEMSP		VL2440		104553	93303	108658	138558	267487	
17	SVN	FPO	DEMSP	NA	VL0006			738	788	695	1124	382
17	SVN	FPO	DEMSP	NA	VL0012			846	788	695	1145	382
17	SVN	FPO	DEMSP	NA	VL0612			107			20	
17	SVN	FPO	DEMSP	NA	VL1218						6632	11027
17	SVN	FPO	DEMSP	NA	VL1224						6632	11027
17	SVN	FYK	DEMSP	NA	VL0006			165	495	637	18	458
17	SVN	FYK	DEMSP	NA	VL0012			165	554	637	18	458
17	SVN	FYK	DEMSP	NA	VL0612				59			
17	SVN	GND	SPF	20D40	VL0012			1135	227	92	219	141
17	SVN	GND	SPF	20D40	VL0612			1135	227	92	219	141
17	SVN	GND	SPF	20D40	VL1218					355		
17	SVN	GND	SPF	20D40	VL1224					355		
17	SVN	GNS	DEMSP	16D20	VL0006			3624	3368	4616	4970	6367
17	SVN	GNS	DEMSP	16D20	VL0012			20524	20108	20482	47601	53623
17	SVN	GNS	DEMSP	16D20	VL0612			16900	16739	15893	42671	47256
17	SVN	GNS	DEMSP	16D20	VL1218			67	996	8602	4938	861
17	SVN	GNS	DEMSP	16D20	VL1224			67	996	8602	4938	861
17	SVN	GTR	DEMSP	50D100	VL0006			2767	1608	3570	7475	6644
17	SVN	GTR	DEMSP	50D100	VL0012			29427	37010	75895	81751	78489
17	SVN	GTR	DEMSP	50D100	VL0612			26660	35402	72386	74276	71844
17	SVN	GTR	DEMSP	50D100	VL1218			15970		7548	5137	1387
17	SVN	GTR	DEMSP	50D100	VL1224			15970		7548	5137	1387
17	SVN	LHP-LHM	CEP	NA	VL0006							11
17	SVN	LHP-LHM	CEP	NA	VL0012						3	11
17	SVN	LHP-LHM	CEP	NA	VL0612						3	
17	SVN	LHP-LHM	FINF	NA	VL0006					4	3	9
17	SVN	LHP-LHM	FINF	NA	VL0012			10		4	20	12
17	SVN	LHP-LHM	FINF	NA	VL0612			10			17	4
17	SVN	LLS	DEMSP	NA	VL0006			22	13	36	31	22
17	SVN	LLS	DEMSP	NA	VL0012			153	637	36	40	421
17	SVN	LLS	DEMSP	NA	VL0612			131	624		8	399
17	SVN	LLS	DEMSP	NA	VL1218					27		
17	SVN	LLS	DEMSP	NA	VL1224					27		
17	SVN	OTB	DEMSP	40D50	VL0006			17				4
17	SVN	OTB	DEMSP	40D50	VL0012			17615	19313	20311	18128	14912
17	SVN	OTB	DEMSP	40D50	VL0612			18935	27569	34965	37112	40305
17	SVN	OTB	DEMSP	40D50	VL1218			41539	54928	76356	79234	84796
17	SVN	OTB	DEMSP	40D50	VL1224			41539	54928	76356	79234	84796
17	SVN	OTB	DEMSP	40D50	VL2440					600	350	
17	SVN	OTM	MDPSP	20D40	VL1218						47	196
17	SVN	OTM	MDPSP	20D40	VL1224						47	196
17	SVN	OTM	MDPSP	20D40	VL2440							550
17	SVN	PS	SPF	14D16	VL0006							3
17	SVN	PS	SPF	14D16	VL0012			3169	4648	6209	4073	3009
17	SVN	PS	SPF	14D16	VL0612			3169	4648	6209	4073	3005
17	SVN	PS	SPF	14D16	VL1218			14080	15883	11865	12994	20598
17	SVN	PS	SPF	14D16	VL1224			14080	15883	11865	12994	20598
17	SVN	PTM	SPF	20D40	VL2440			100585	91719	110404	69808	102116

5.52.3. *Scientific surveys*

5.52.3.1. SoleMon

5.52.3.1.1. *Methods*

Six *rapido* trawl fishing surveys were carried out in GSA 17 from 2005 to 2008: two systematic "pre-suveys" (spring and fall 2005) and four random surveys (spring and fall 2006, fall 2007-2008) stratified on the basis of depth (0-30 m, 30-50 m, 50-100m). Hauls were carried out by day using 2-4 *rapido* trawls simultaneously (stretched codend mesh size = 40.2 ± 0.83). The following number of hauls was reported per depth stratum (Tab. 5.52.3.1.1.1).

Tab. 5.52.3.1.1.1 Number of hauls per year and depth stratum in GSA 17, 2005-2009.

Depth strata	Spring 2005	Fall 2005	Spring 2006	Fall 2006	Fall 2007	Fall 2008-2009
0-30	30	30	20	35	32	39
30-50	14	12	10	20	19	17
50-100	24	15	8	8	11	11
HR islands	0	5	4	4	0	0
TOTAL	68	62	42	67	62	67

Abundance and biomass indexes from *rapido* trawl surveys were computed using ATrIS software (Gramolini *et al*., 2005) which also allowed drawing GIS maps of the spatial distribution of the stock, spawing females and juveniles. Underestimation of small specimens in catches due to gear selectivity was corrected using the selective parameters given by Ferretti and Froglia (1975).

The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

$$Yst = \Sigma\,(Yi*Ai) / A$$

$$V(Yst) = \Sigma\,(Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*., 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.52.3.1.2. Geographical distribution patterns

According to data collected during SoleMon surveys (Fabi *et al.*, 2009), age class 0+ aggregates inshore along the Italian coast, mostly in the area close to the Po river mouth (Fig. 5.52.3.1.2.1). Age class 1+ gradually migrates off-shore and adults concentrate in the deepest waters located at South West from Istria peninsula.

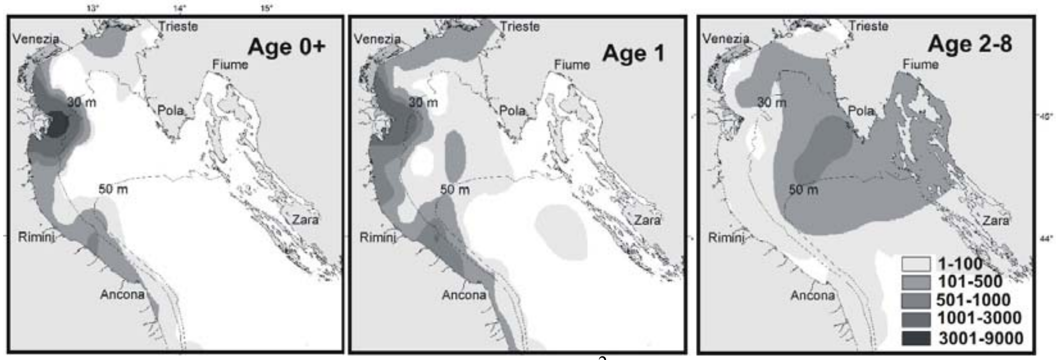


Fig. 5.52.3.1.2.1 Example of abundance indices (ind.· km^{-2}) for sole from SoleMon survey carried out in GSA 17 (fall 2007) interpolated using Kriging (Fabi *et al.*, 2009).

5.52.3.1.3. Trends in abundance and biomass

The SoleMon trawl surveys provided data either on sole total abundance and biomass as well as on important biological events (recruitment, spawning).

Fig. 5.52.3.1.3.1 shows the abundance and biomass indices of sole obtained from 2005 to 2008; slightly increasing trends occurred till fall 2007, followed by a decrease in fall 2008-2009.

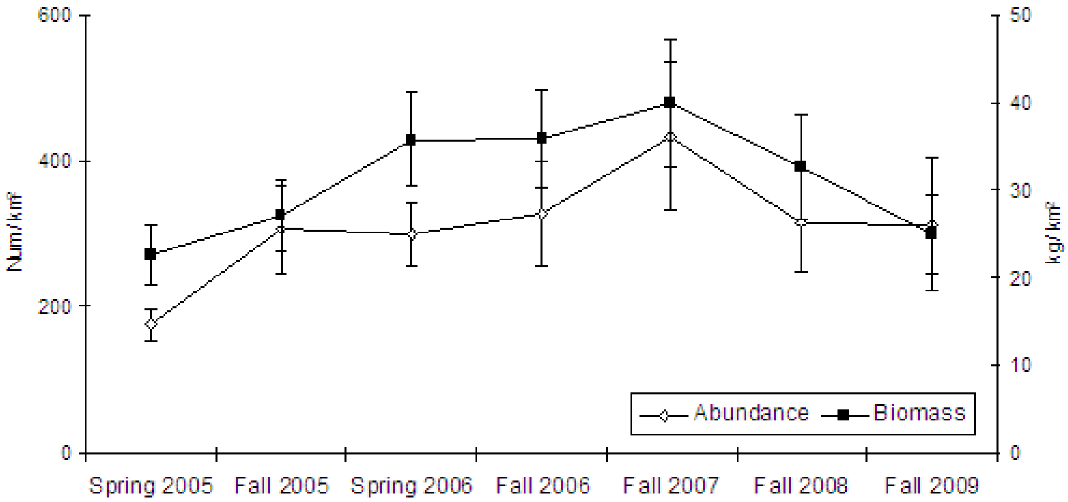


Fig. 5.52.3.1.3.1 Abundance and biomass indices of sole obtained from SoleMon surveys.

The recruitment showed a fluctuating trend with the lowest values in 2006 and 2008 (Fig. 5.52.3.1.3.2). The number and biomass of spawners remained practically constant from 2005 to 2008 and decreased in 2009 (Fig. 5.52.3.1.3.3).

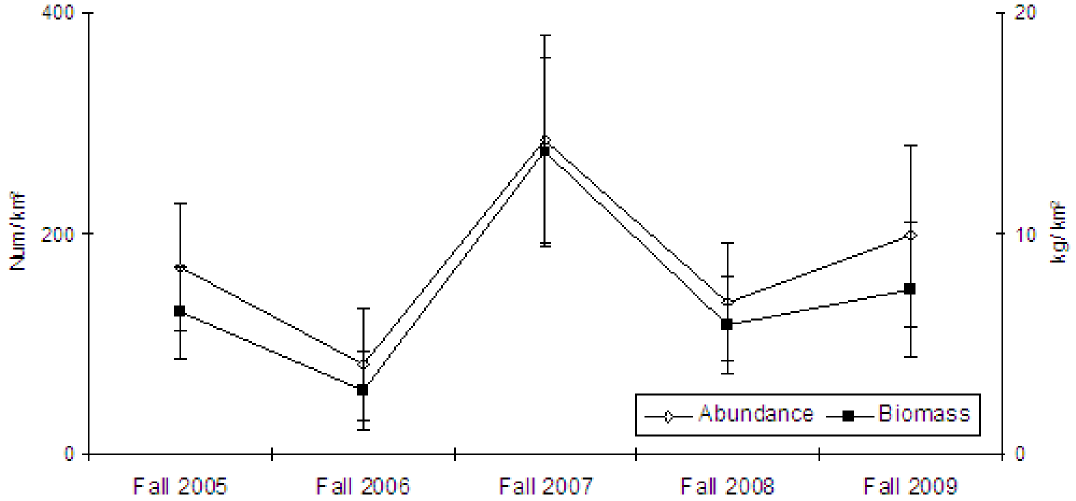


Fig. 5.52.3.1.3.2 Abundance and biomass indices of recruits of sole obtained from SoleMon surveys.

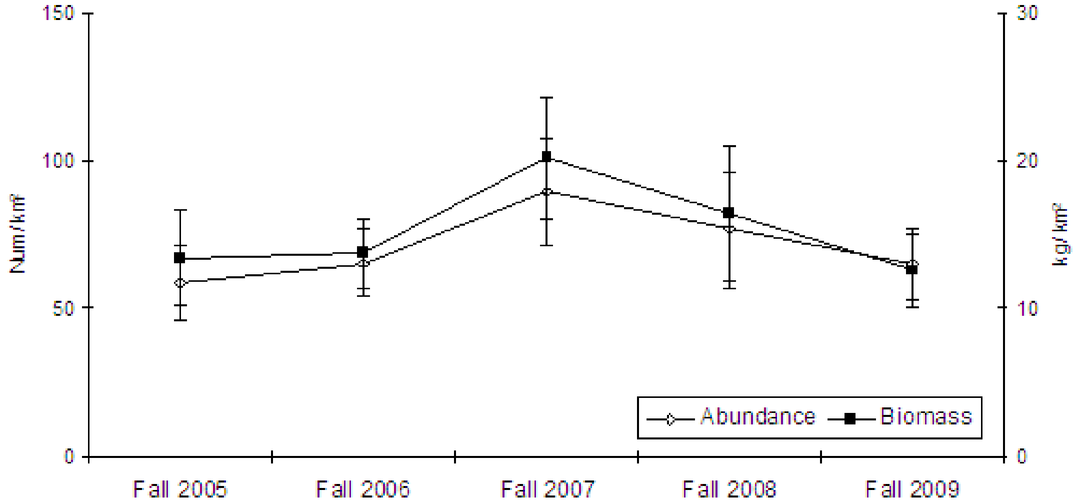


Fig. 5.52.3.1.3.3 Abundance and biomass indices of spawners of sole obtained from SoleMon surveys.

5.52.3.1.4. Trends in abundance by length or age

Fig. 5.52.3.1.4.1 displays the stratified abundance indices obtained in the GSA 17 in the years 2005-2009.

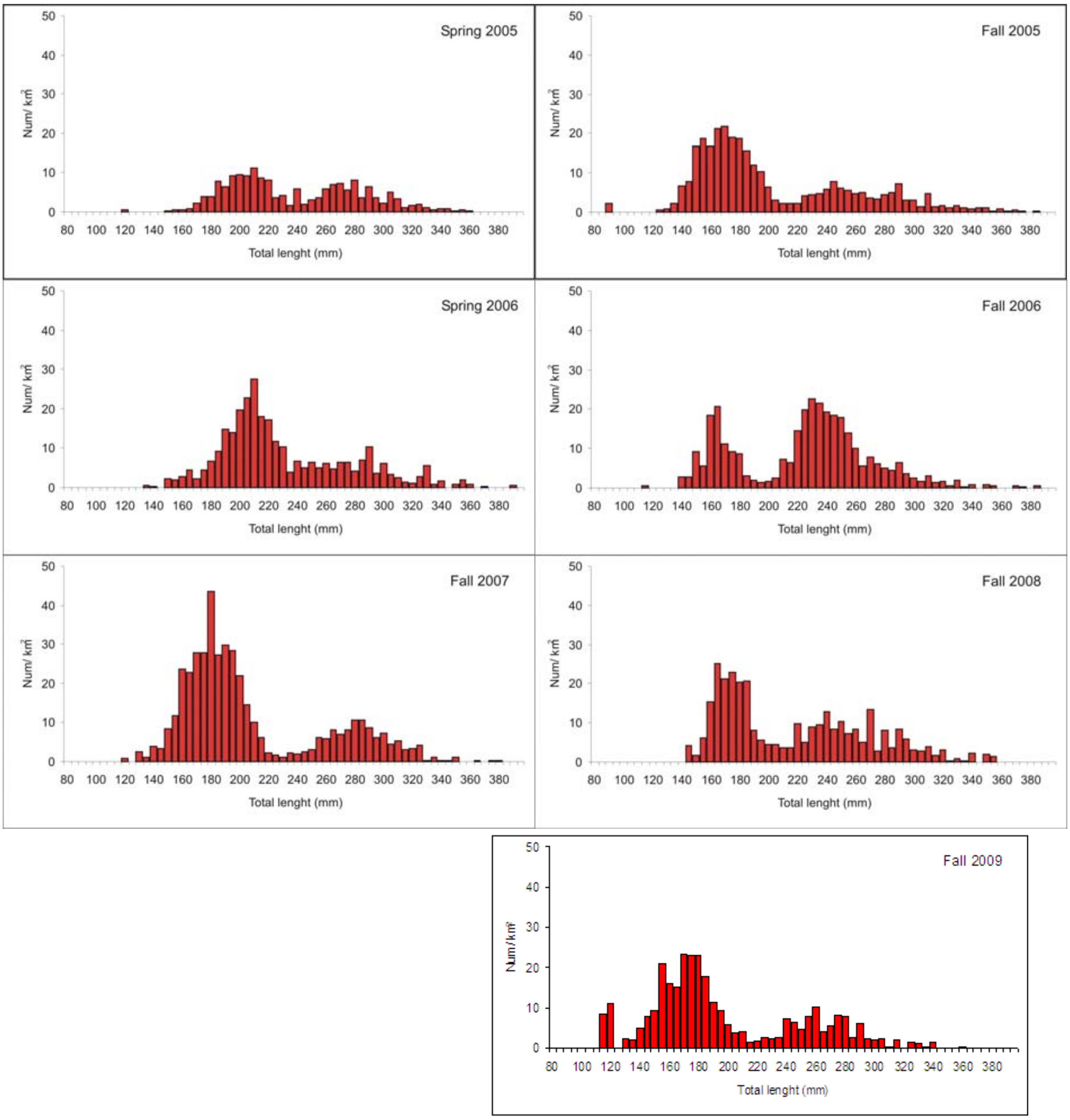


Fig. 5.52.3.1.4.1 Stratified abundance indices by size, 2005-2008.

5.52.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.52.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.52.4. Assessment of historic stock parameters

Sole has been object of assessments in the GSA 17 and results are published and regularly updated in the GFCM SAC sheets and in SGMED. The assessments, often performed with different approaches, showed substantially convergent results.

From the SGMED-09-02, the sole stock in the GSA 17 seems to be overexploited, as shown by the results of the analytical models (reference points as F_{max}, $F_{0.1}$). A growth overfishing situation was detected, with high fishing mortality on 1+ and 2+ age classes.

SGMED-10-02 has updated the assessment carried out during the SGMED 09-02 with 2009 catch data. Also the maturity ogive, the mean weight at age and the natural mortality has been updated on the base of new biological data available for the years 2008-2009. Anyway the updates did not determine a considerable variation of the parameters.

5.52.4.1. Method 1: XSA

5.52.4.1.1. Justification

Considering the variability observed in the recruitment in SGMED-09-02, the assessment is based on non-equilibrium method. VPA Lowestoft software suite (Darby and Flatman 1994) was used and XSA was the assessment method. A separable VPA (Pope and Shepherd, 1982) was also run as exploratory analysis for this stock.

5.52.4.1.2. Input parameters

Catch at age data 2005-2009 from all fishing ports from GSA17.
Biological sampling 2005-2006 and 2008-2009 for Maturity at age and Weight-Length relationships (SoleMon project).
Tuning data from SoleMon surveys carried out in fall for the years 2005-2009.
A vector of natural mortality rate at age was estimated using the PRODBIOM spreadsheet (Abella *et al.*, 1997).
These data come from independent monitoring activities performed by the research institutes working in the GSA 17 (Tab. 5.52.4.1.2.1).

Tab. 5.52.4.1.2.1 Input parameters.

Catch at age in numbers (x 1000)						
	0	1	2	3	4	5+
2005	2190	12910	3120	138	11	8
2006	2629	15151	1637	159	20	10
2007	3813	11205	1768	186	38	14
2008	5779	15675	1830	181	39	14
2009	4957	15195	2191	190	41	21

Survey indexes (N. ind. km^{-2})							
	0	1	2	3	4	5	6+
2005	169	82	36	12	3	1.5	0.4
2006	92	179	43	10	1	0.7	0.5
2007	205	138	72	18	1	0.4	0.2
2008	117	123	61	10	6	0.1	0.1
2009	177	83	47	6	1	0.2	0.1

Mean weight in catch						
PERIOD	0	1	2	3	4	5+
2005-2009	0.024	0.104	0.207	0.304	0.380	0.522

Growth parameters			
PERIOD	L_8	K	T_0
2005-2009	39.6 cm	0.44 y^{-1}	-0.46 y

Length-weight relationships		
PERIOD	a	b
2005-2009	0.007	3.0638

Maturity at Age						
PERIOD	0	1	2	3	4	5+
2005-2009	0	0.16	0.76	0.96	0.99	1.00

Natural mortality (M)						
PERIOD	0	1	2	3	4	5+
2005-2009	0.70	0.35	0.28	0.25	0.23	0.22

5.52.4.1.3. Results

A separable VPA was run as exploratory analysis. Log catchability residual plots were produced (Fig. 5.52.4.1.3.1) and no major conflict between ages seems to appear.

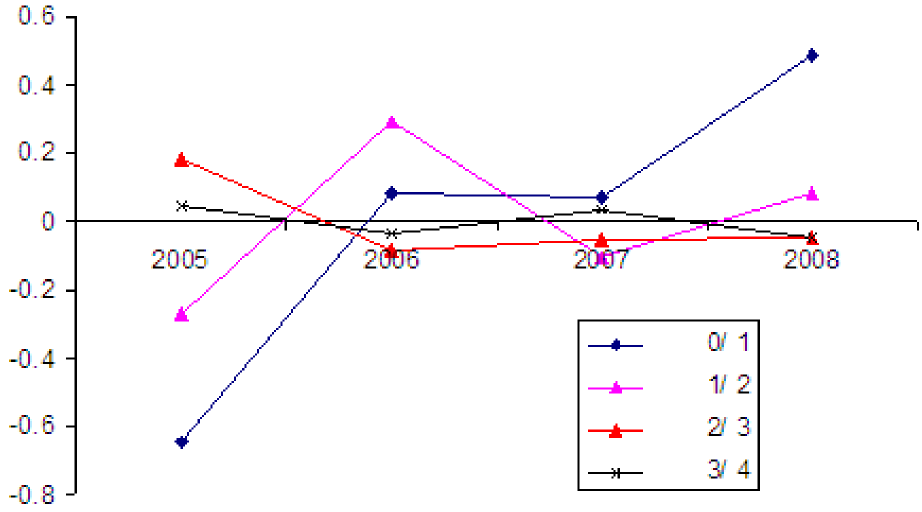


Fig. 5.52.4.1.3.1 Residuals of log catchabilities.

Then a XSA assessment was made. The main settings for the XSA are the following:

- F_{bar} 0-4.
- Catchability dependent on stock size for ages < 1.
- Catchability independent of age for ages >= 1
- S.E. of the mean to which the estimates are shrunk = 0.50
- Minimum S.E. for population estimates derived from each fleet = 0.30

XSA Diagnostics in the form of residuals by survey data are shown in the figure 5.52.4.1.3.2.

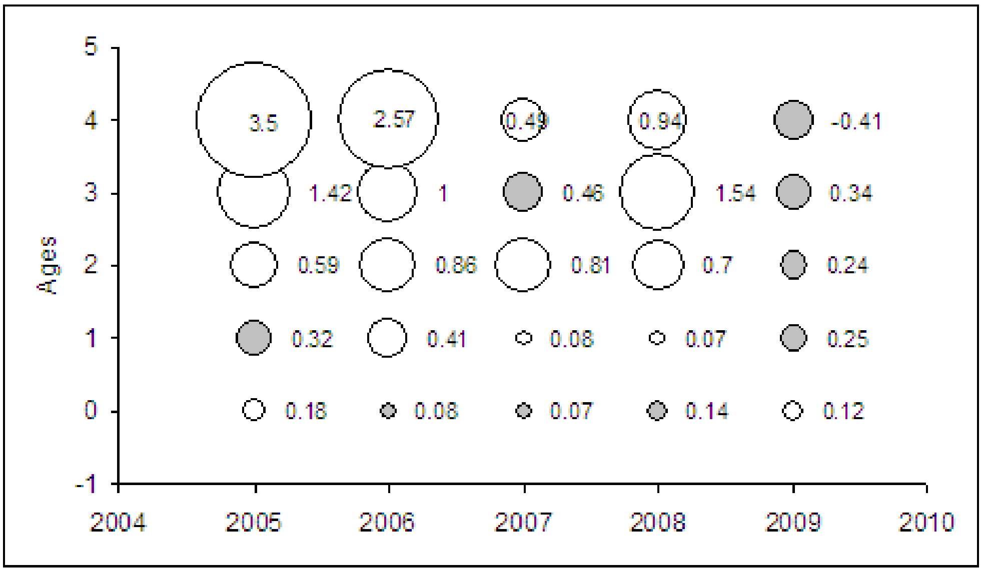


Fig. 5.52.4.1.3.2 Residuals by survey.

The inclusion of tuning data from *rapido* trawl commercial fleet of Rimini did not provide additional information or different results. Therefore, the definitive assessment only included tuning data from SoleMon survey

Figure 5.52.4.1.3.3 present the main results from the XSA: fishing mortality, relative F at age, total biomass, spawning stock biomass (SSB), recruitment.

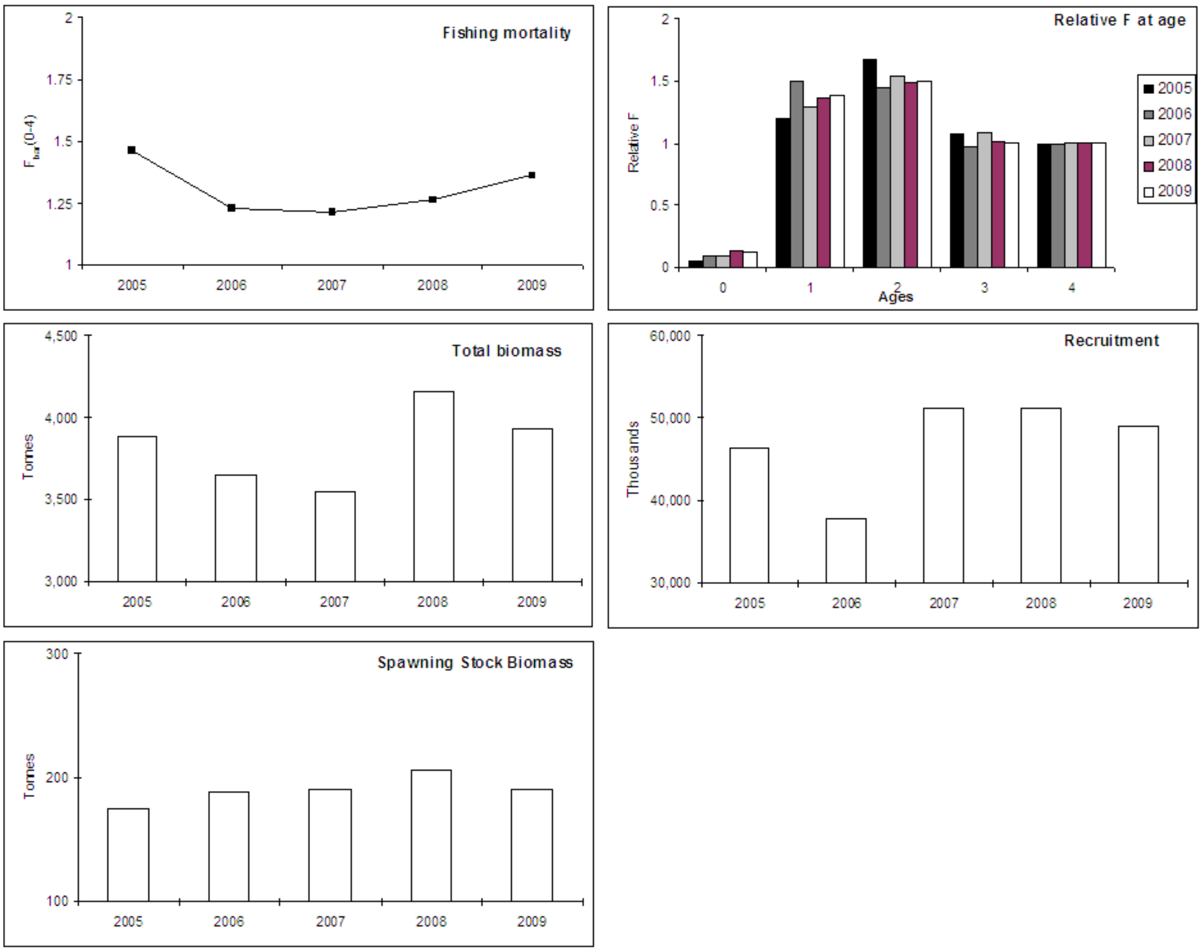


Fig. 5.52.4.1.3.3 Final XSA assessment results.

Exploitation decreased from 2005 to 2006, was constant in 2006-2007 and increased in 2008-2009. The most recent estimate of fishing mortality ($F_{0\text{-}4}$) is 1.36, the highest values of relative F are for ages 1 and 2.

Recruitment varied without any trend in the years 2005-2009, reaching a minimum in 2006.

The total biomass regularly decreased from 2005 to 2007 and increased in 2008 reaching the maximum value, but decreased again in 2009. The SSB reached the minimum value in 2005, was constant in 2006 and 2007, increased in 2008 and decreased in 2009.

Tab. 5.52.4.1.3.1 Estimated fishing mortality at age, 2005-2009.

AGE	2005	2006	2007	2008	2009
0	0.0476	0.0849	0.0921	0.1384	0.114
1	1.2026	1.4972	1.2921	1.3574	1.3822
2	1.6741	1.4503	1.5336	1.4837	1.4979
3	1.0775	0.9763	1.0803	1.0127	1.0015
4	0.9983	0.9913	1.0019	1.0079	1.0043
5+	0.9983	0.9913	1.0019	1.0079	1.0043

Tab. 5.52.4.1.3.2 Estimated stock numbers at age, 2005-2009.

AGE	2005	2006	2007	2008	2009
0	46340	37720	51294	51211	48974
1	18593	21468	16878	22785	21358
2	3930	2265	2410	2488	2898
3	197	258	289	284	289
4	16	32	61	61	62
5+	11	15	22	21	31

Tab. 5.52.4.1.3.3 Summary table of stock parameters obtained from XSA, 2005-2009.

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 0- 4
2005	46340	3886	175	2067	11.8094	0.9884	1.4595
2006	37720	3650	188	2008	10.7078	0.9849	1.227
2007	51294	3548	190	1673	8.7957	0.9835	1.2109
2008	51211	4157	206	2184	10.5813	0.9816	1.2613
2009	48974	3936	190	2135	11.2559	0.9544	1.3605

5.52.4.2. Method 2: SURBA

5.52.4.2.1. Justification

The availability of a time series of data from SoleMon surveys allows the use of the SURBA assessment tool. Using the software, the evolution of fishing mortality rates of sole in the GSA 17 was reconstruct starting from the analysis of the length frequency distribution (LFD).

5.52.4.2.2. Input parameters

The main input parameters to run the SURBA-survey based stock analysis are abundances, natural mortality rates and catchability. The parameters used in this analysis were the same used in the XSA analysis.

5.52.4.2.3. Results

The results and the diagnostic of the analyses are summarized in Figures 5.52.4.2.3.1 and 5.52.4.2.3.2 respectively. The results of the model are in general accordance with the previous method providing the same perception of the state of the stock. Comparison between observed *vs* fitted data obtained with SURBA (Figures 5.52.4.2.3.2 A) shows an adequate fitting of the model in sole data in GSA 17.

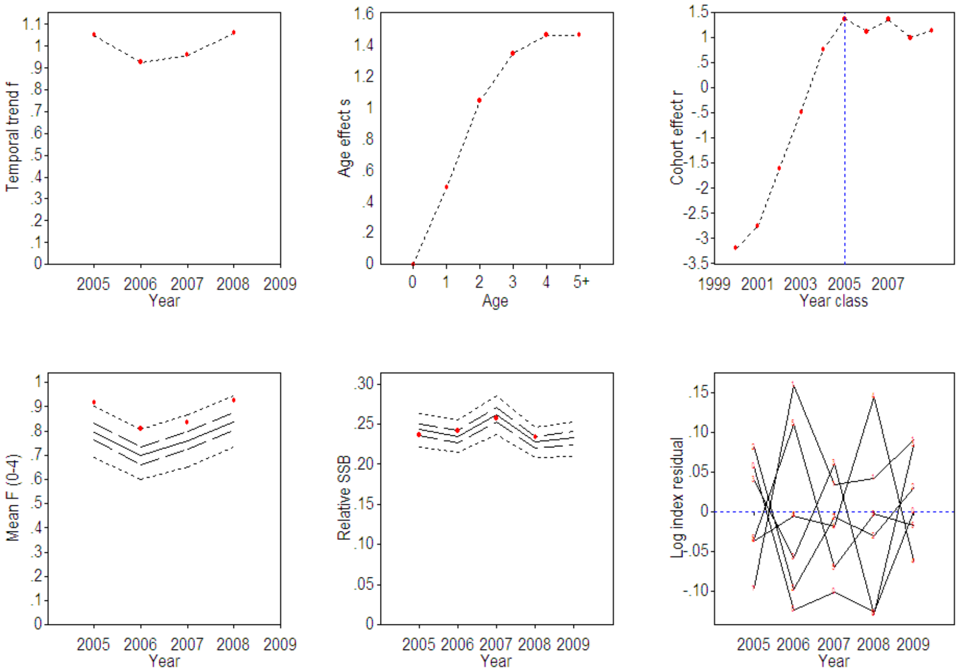


Fig. 5.52.4.2.3.1 Trends in stock parameters (SoleMon survey) in GSA 17 from SURBA.

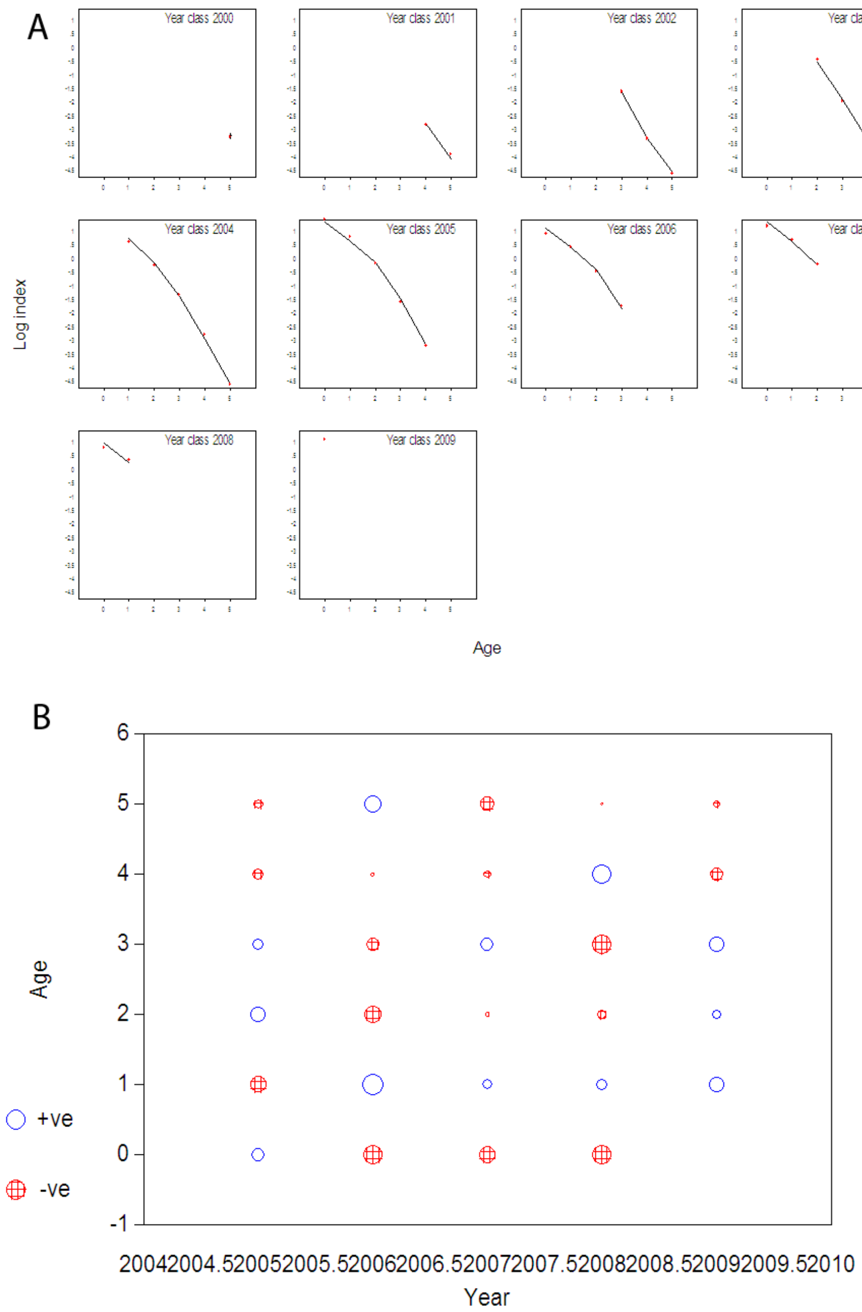


Fig. 5.52.4.2.3.2. Model diagnostic (SoleMon survey) in GSA 17 from SURBA. Comparison between observed (points) and fitted (lines) of SoleMon survey abundance indices, for each year (A); bubble plot of log-index residuals by age (B).

5.52.5. Long term prediction

5.52.5.1. Justification

The same analysis performed in the SGMED-09-02 is presented to estimate the biological reference points (BRP).

Availability of biological parameter and length at first capture allows to quantify by simulation the likely changes in Y, B and SSB per recruit in function of fishing mortality (F) with the Yield package.

5.52.5.2. Input parameters

Growth, length-weight relationship, natural mortality and maturity ogive were the same used in the previous paragraphs. Length at first capture was 16 cm TL (about 0.7 year old).

A guess estimate of uncertainty in terms of coefficient of variation (CV=0.2) was added to each parameter.

Beverton and Holt stock-recruit relationship commonly employed for North Sea flatfish (Kell *et al.*, 2005; Pilling *et al.*, 2008) was used with steepness of 0.9 and virgin SSB of 13000 t. The value of steepness represents a hypothesis based on the high resilience of the stocks at low spawning-stock size. The value of virgin SSB was estimated from previous analyses carried out by VIT package. The recruitment variability among years was estimated as CV=0.3 from recruit indices obtained in trawl surveys.

5.52.5.3. Results

Estimation of Y and SSB per recruit are shown in Fig 5.52.5.3.1.

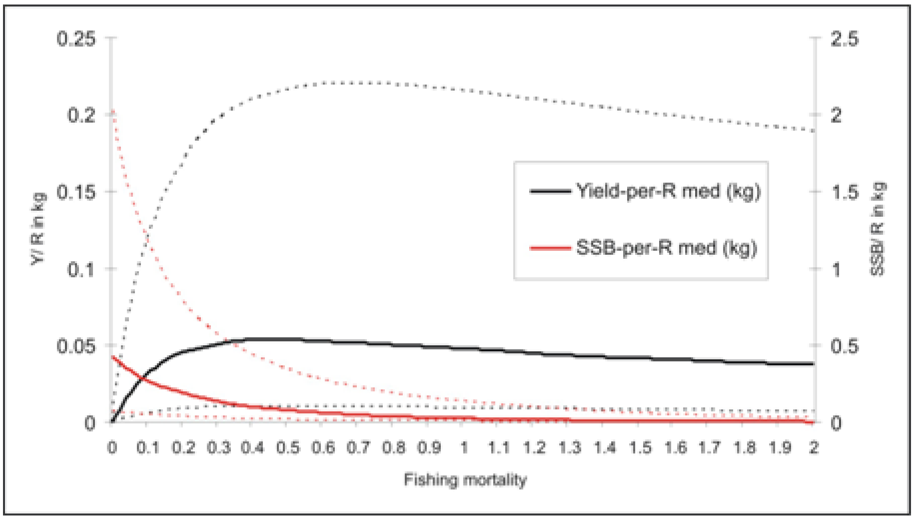


Fig. 5.52.5.3.1 Yield and spawning stock biomass per recruit and corresponding uncertainty of sole in the GSA 17 according to the Yield Package.

Searching for biological reference points (BRP) through 1000 simulation produced the median values reported in Tab. 5.52.5.3.1. Y/R_{max}, F_{max} and Y/R_{ref}, F_{ref}, the two latter corresponding to Y/R and F at SSB/initial SSB = 0.30, were assumed as limiting reference points. Whereas $Y/R_{0.1}$ and $F_{0.1}$, should be considered as target reference points.

RPs suggest an overfishing situation for the stock considering that F current (1.35 from XSA) is much higher than the limit and target RPs F.

The effect of several bad recruitment years in a row has been evaluated using the transient analysis of SSB. A fishing mortality rate of 0.24 will result in a probability of 0.1 of the SSB falling below 0.2 of its unexploited level at least once in 20 years.

Tab. 5.52.5.3.1 Yield (kg) per recruit and fishing mortality based BRP of sole for GSA 17 according to the Yield package.

Yield based RP	value	F based RP	value
Y/R_{max}	0.054	F_{max}	0.46
Y/R_{ref}	0.051	F_{ref}	0.32
$Y/R_{0.1}$	0.048	$F_{0.1}$	0.26

5.52.6. Data quality and availability

Data used in the present assessment have been compared with the official DCF data collected in Italy in the framework of the Data Collection Regulation (Table 5.52.6.1). The sampling regarding the age and the length structures of the landings from the official DCF data did not provide useful data for 2007 and 2008. As regarding the total landings, there is a high level of similarity comparing the official DCR data and the data collected in the framework of other projects used in the present assessment. The most important difference (753 t) has been observed only in 2008, likely due to the underestimation of the “rapido” trawl fishing activity in the DCR data. The Slovenian data were not available in the period when the assessment was performed. However, considering its relatively low amount, they should not change the results of the assessment substantially. At present, data on sole are not available from the Croatian part; because sole is considered under the “mixed flatfish” category in the Croatian fishery statistics. However, landings of around 200 t of *S. solea* per year have been suggested, mainly caught by small scale fisheries using gill net. In 2009, 150 tons were considered a good estimation on the base of the Croatian fishery data presented in the report of the 12th session of the Scientific Advisory Committee (GFCM: XXXIV/2010/Inf.9). The length frequency distributions from 2005 to 2009 of the Croatian catches derived from the demography of common sole observed in the hauls performed close to the Croatian waters during the SoleMon survey.

The official survey data from MEDITS were not used in the present nor in the previous assessments (SGMED-09-02), because the otter trawl net used in the MEDITS survey has very low catchability for species as common sole, thus does it not provide data representative on the status of the stocks. The use of independent SoleMon survey date were useful in the present assessment to provide an overall perception of the status of the stock but also tuning values for the XSA and input data for the SURBA analysis.

Fishery dependent data for 2009 was not submitted by the Italian authorities. MEDITS data from 1994 to 2001 as well as GRUND data was not submitted by the Italian authorities.

Table 5.52.6.1 Landings (t) of common sole from GSA 17.

	2005	2006	2007	2008	2009
DCR Italian landings	1662	1891	1492	1231	-
SGMED landings*	1867	1808	1473	1984	2135
Slovenian landings	6.4	5.6	8.3	6.2	-
Croatian landings*	200	200	200	200	150

*used in the present assessment

5.52.7. Scientific advice

Considering the results of XSA and SURBA analyses, it can be concluded that the resource is over-exploited. A reduction of fishing pressure, especially by *rapido* trawling, would be recommended, also taking into account that the exploitation is mainly orientated towards juveniles and the success of recruitment sems to be strictly related to environmental conditions (Domenichetti *et al.*, 2009). Hence, in the case of both increasing fishing effort and yearly bad recruitment, there could be a high risk of stock depletion. A two–months closure for rapido trawling inside 11 km off-shore along the Italian coast, after the biological fishing ban (August), would be advisable to reduce the portion of juvenile specimens in the catches. For the same reason, specific studies on rapido trawl selectivity are necessary. In fact, it is not sure that the adoption of a larger mesh size would correspond to a decrease of juvenile catches, considering that the mesh opening currently used by the Italian rapido trawlers is larger (48 mm or more) than the legal one. The same uncertainty regards the adoption of a square mesh.

SSB was practically constant over the 4 years, maybe because, as observed during the SoleMon project, in late fall - winter the main spawning area is only partially exploited by the Croatian set netters and Italian fleets (Figure 5.52.7.1). The safeguard of such area (identified by the *rapido* trawl survey) to prevent a possible future exploitation might be crucial for the sustainability of the Adriatic sole stock.

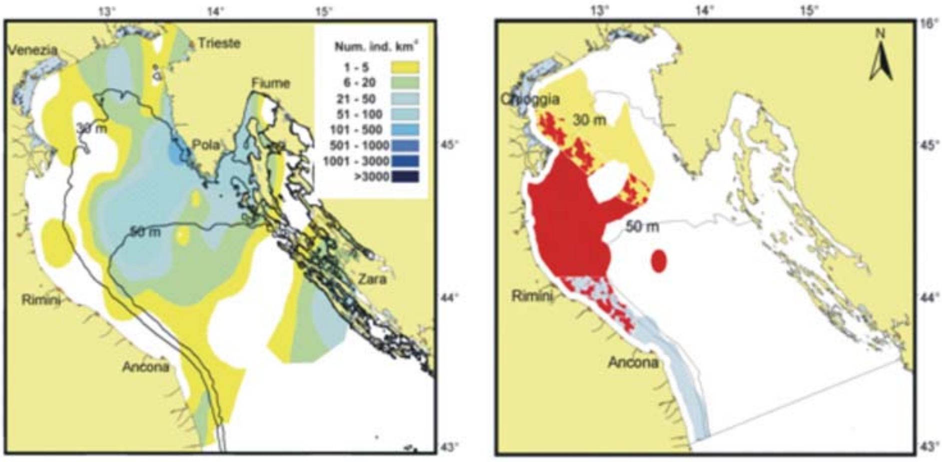


Figure 5.52.7.1 Spatial distribution of spawning females in fall (left) and fishing grounds of the Italian rapido trawl fleets (right; in yellow Chioggia rapido trawl fleet; in red Rimini rapido trawl fleet; in light blue Ancona rapido trawl fleet).

5.52.7.1. Short term considerations

5.52.7.1.1. State of the spawning stock size

According to the XSA and SURBA analyses the SSB was practically constant in the period considered. In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the stock size.

5.52.7.1.2. State of recruitment

According to the XSA and SURBA analyses the recruitment of sole in GSA 17 fluctuated since 2005, despite of the fact that the SSB remained practically constant during this period.

5.52.7.1.3. State of exploitation

SGMED-10-02 proposes $F_{0.1}$=0.26 as limit management reference point consistent with high long term yield. Based on the XSA estimates of the fishing mortality in 2009 (F_{0-4}=1.36), which by far exceeds $F_{0.1}$, SGMED-10-02 concludes that the resource is subject to overfishing. SGMED recommends reductions in fishing effort of the relevant fleets and consistent reductions in landings by means of a multi-annual management plan being agreed and implemented. Such plan needs to account for multi-species effects of such fisheries.

5.53. Stock assessment of blue and red shrimp in GSA 06

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.53.1. Stock identification and biological features

5.53.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.53.1.2. Growth

Growth parameters used were those from Garcia-Rodriguez (2003) over length distributions analysis (L_{inf} = 77.0; K = 0.38; t_0= -0.065), and length-weight relationship (a= 0.0024; b= 2.467).

5.53.1.3. Maturity

Maturity ogive was taken from García Rodriguez (2003), with size at first maturity (50 %) at 23.5 mm CL.

Age class	0	1	2	3	4	5
Maturity ratio	0.07863309	0.7669088	0.9980806	1	1	1

5.53.2. Fisheries

5.53.2.1. General description of fisheries

Blue and red shrimp (*Aristeus antennatus*) is one of the most important crustacean species for the trawl fisheries developed along the GFCM geographical sub-area Northern Spain (GSA 06). This resource is an important component of commercial landings in some ports of the Mediterranean Northern Spain, and is a target species of a specific trawl fleet. The red shrimp has a wide bathymetric distribution, between 80 and 3300 m depth (Sardà *et al*., 2004), and some areas may constitute a reservoir for the resource since they are located a long way from ports and in deeper zones up to 1000 m. Females predominate in the landings nearly 80% of the total. Discards of the red shrimp are null. The number of harbours with red shrimp fleets is 14 for the whole area. Exploitation is based on very young age classes, mainly 1 and 0 year old individuals, indicating a dependence on recruitments.

5.53.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.53.2.3. Catches

5.53.2.3.1. Landings

Updated information on landings and effort has been collected on annual basis (2002-2008). Throughout the time series landings fluctuated between 300 and 650 tonnes, with an average of c.a. 500 tonnes, with a recovering trend in 2007 and 2008 (Fig. 5.53.2.3.1.1).

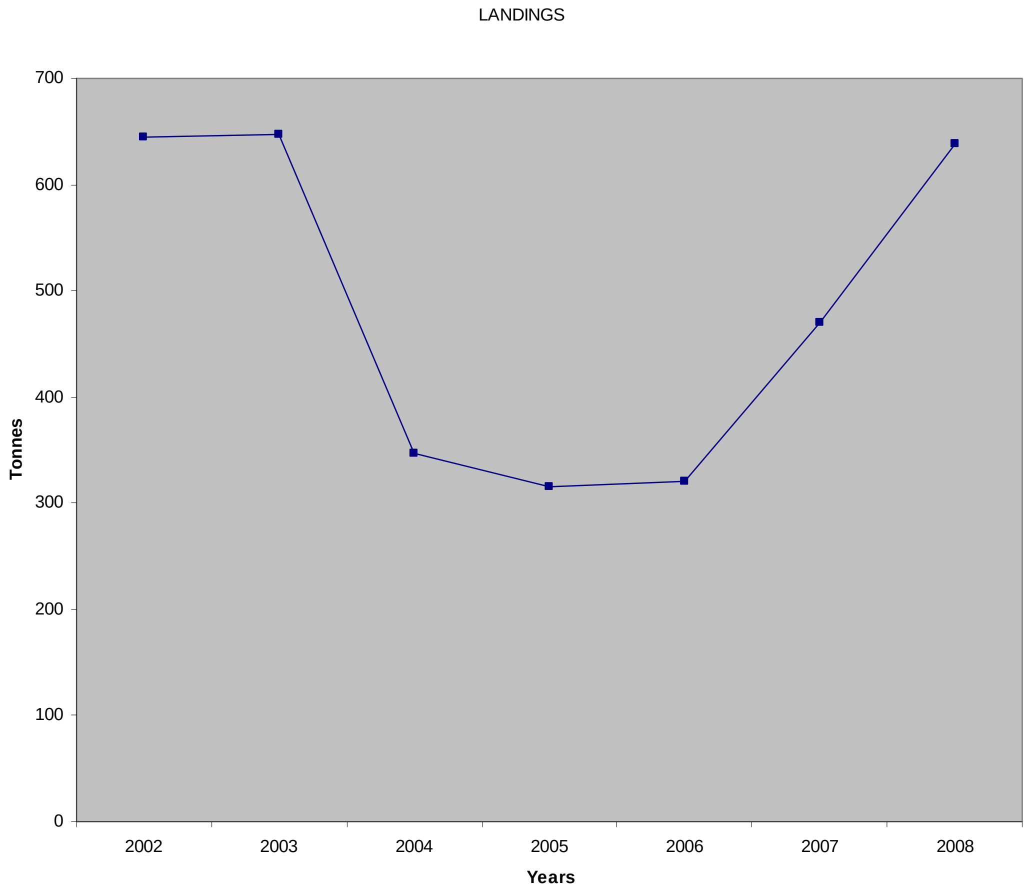


Fig. 5.53.2.3.1.1 Annual blue and red shrimp landings (t) by Spanish trawlers.

Tab. 5.53.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-09-02 through the Data Collection Regulation. Since 2002 the annual landings decreased from 645 t to 316 t in 2005, recovering the initial values in 2008. The landings were only taken by demersal otter trawls.

Tab. 5.53.2.3.1.1 Annual landings (t) by fishing technique in GSA 06.

SPECIES	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
ARA	6	ESP	OTB	645	647	347	316	320	470	638

5.53.2.3.2. Discards

No information was documented during SGMED-10-02.

5.53.2.3.3. Fishing effort

According to data submitted in 2009, fishing effort has reduced from 20,000 days in 2002 to 9,000 in 2006, with an increase thereafter, reaching the 23,000 in 2008. No official data have been reported to SGMED 10-02.

5.53.3. Scientific surveys

5.53.3.1. Medits

5.53.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 06 the following number of hauls were reported per depth stratum (s. Tab. 5.53.3.1.1.1).

Tab. 5.53.3.1.1.1. Number of hauls per year and depth stratum in GSA 06, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA06_010-050	7	8	7	7	7	8	9	8	11	9	9	11	11	6	7	6
GSA06_050-100	19	26	26	26	28	29	29	31	36	38	31	32	34	40	43	41
GSA06_100-200	11	17	17	15	13	17	18	20	20	21	17	18	19	24	30	30
GSA06_200-500	10	12	10	12	7	13	12	16	17	18	16	15	18	18	19	19
GSA06_500-800	6	8	9	7	4	9	6	8	7	11	11	8	10	15	13	13

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or red shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.53.3.1.2. *Geographical distribution patterns*

No analyses were conducted during SGMED-10-02.

5.53.3.1.3. *Trends in abundance and biomass*

Fishery independent information regarding the state of the blue and red shrimp in GSA 06 was derived from the international survey Medits. Figure 5.53.3.1.3.1 displays the estimated trend in blue and red shrimp abundance and biomass in GSA 06.

The estimated abundance and biomass indices were high in 2000- 2002 but varied at a low level since then. The both indices increased significantly in the last two years 2008 and 2009.

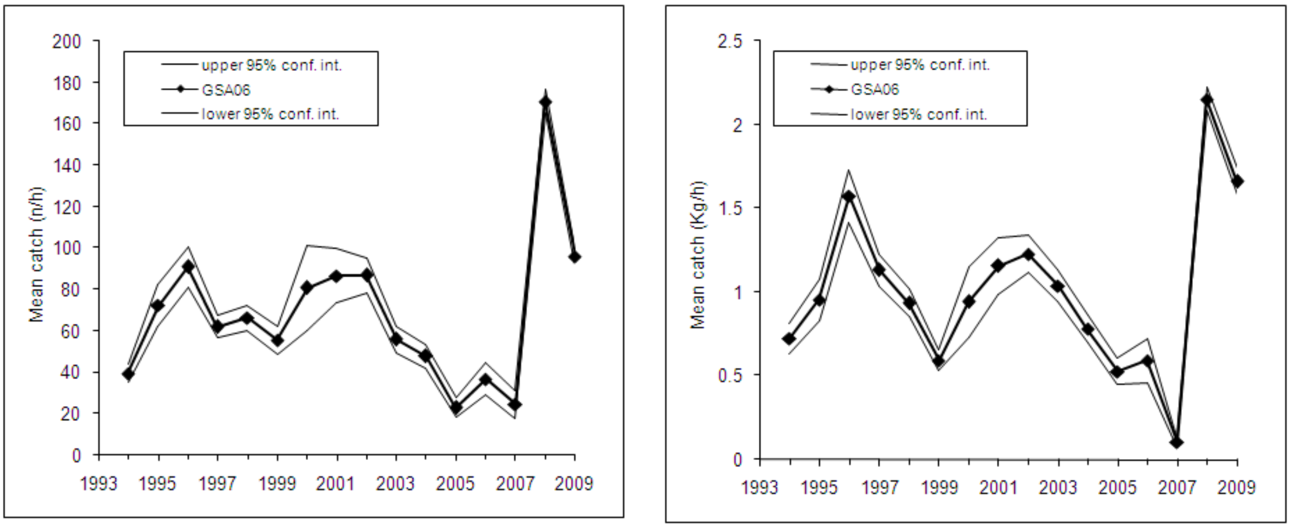


Fig. 5.53.3.1.3.1 Abundance and biomass indices of blue and red shrimp in GSA 06.

5.53.3.1.4. *Trends in abundance by length or age*

The following Fig. 5.53.3.1.4.1 and 2 display the stratified abundance indices of GSA 06 in 1994-2009.

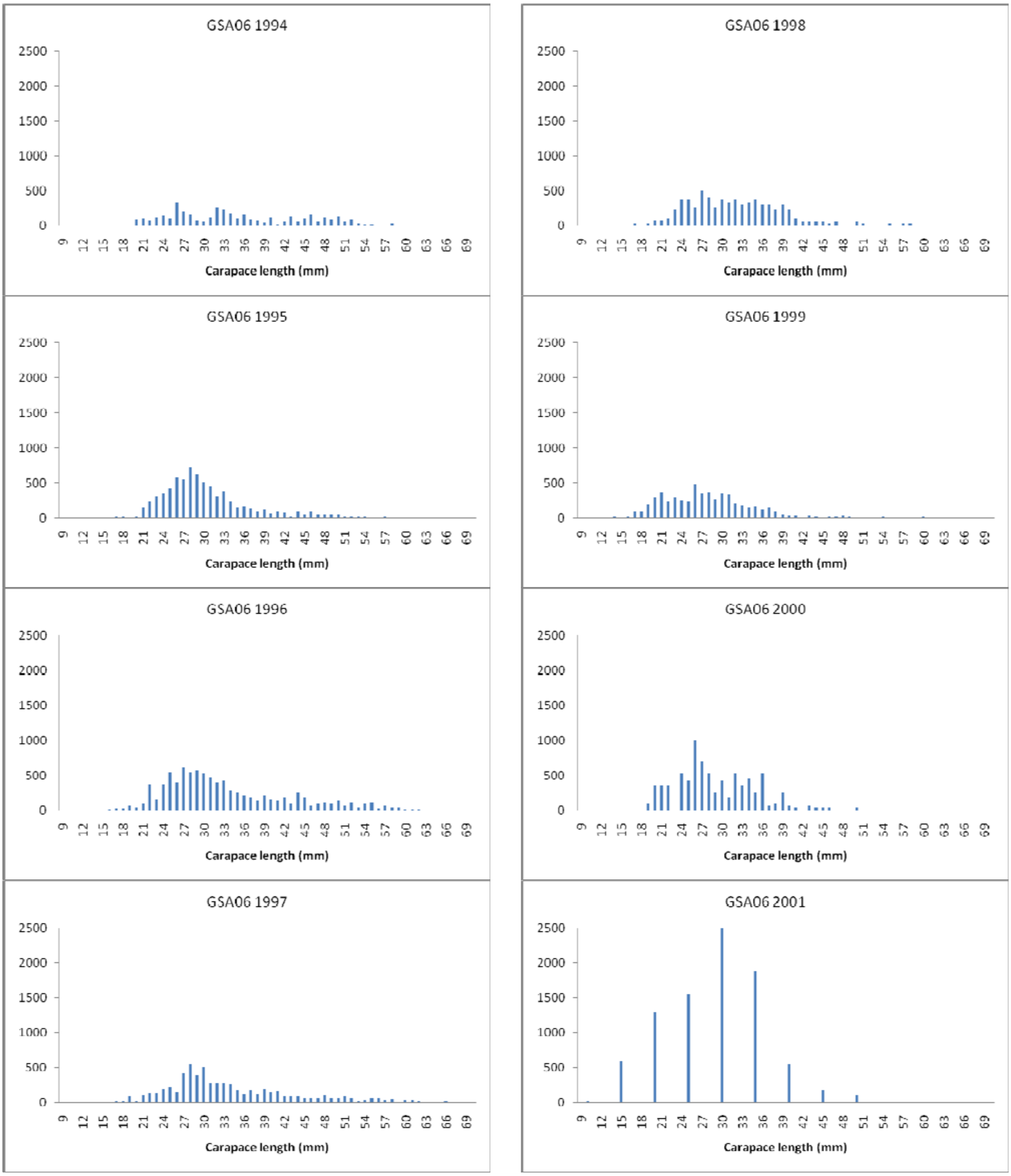


Fig. 5.53.3.1.4.1 Stratified abundance indices by size, 1994-2001.

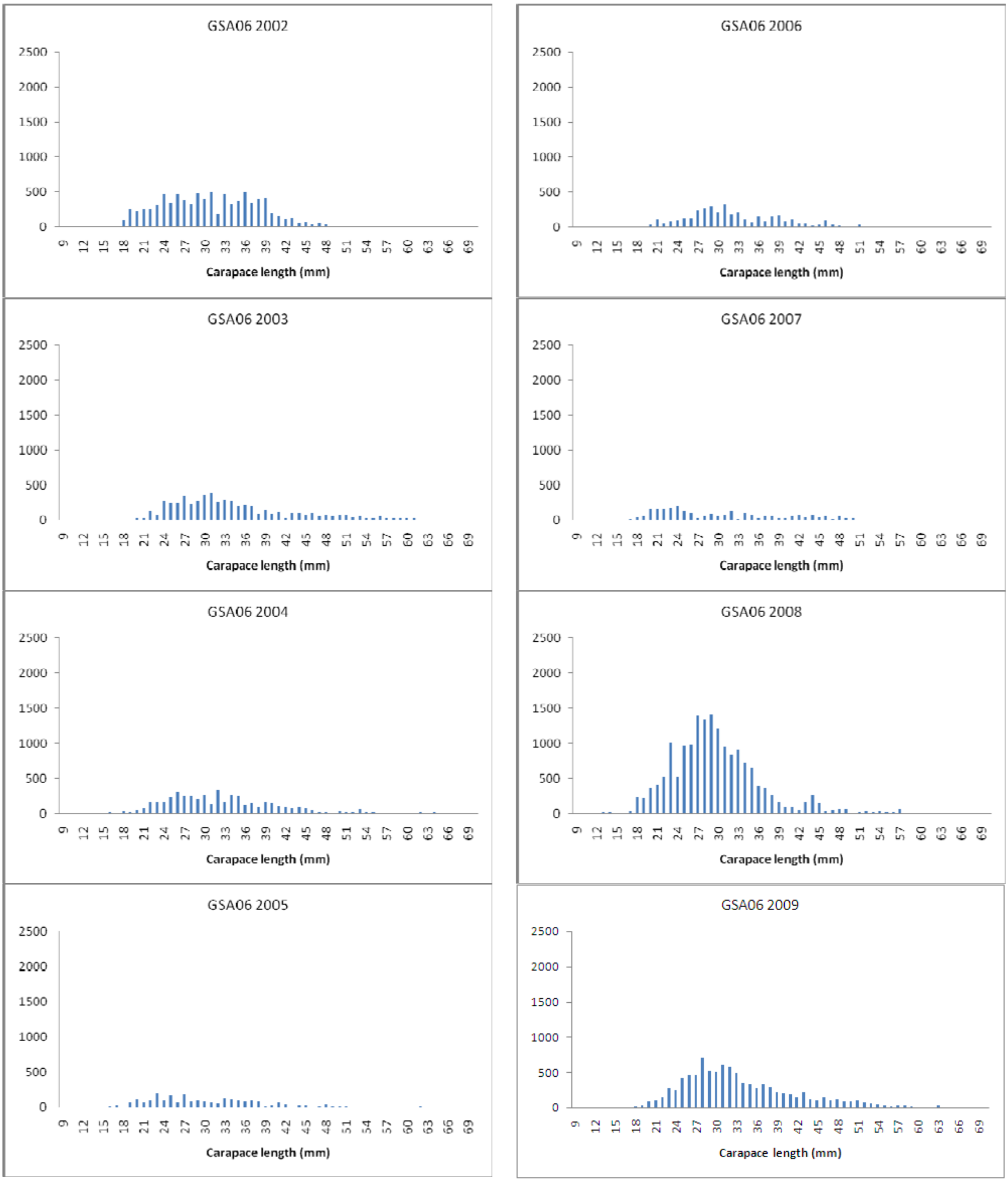


Fig. 5.53.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.53.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.53.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.53.4. Assessment of historic stock parameters

5.53.4.1. Method 1: XSA

5.53.4.1.1. Justification

During the SGMED-09-02, an assessment on red shrimp from GSA 06 was performed. Files dealing with official landings and effort were not available. Consequently data on landings and effort for 2008, were derived, by regression, from the series.

5.53.4.1.2. Input data

Tab. 5.53.4.1.2.1 Input data used in the XSA assessment.

Red shrimp				**Catch at age**			
Age class	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	1724.7	4580.2	3790.5	4160.8	3688.8	4475	9796.5
1	16115.7	14664.6	25356.9	23263.4	23119.8	30558.2	39672.2
2	2525.4	2528.4	1807.6	1695.7	1897.8	2185.1	3859.5
3	313.9	365.6	411	324.3	127.7	221.3	808.1
4+	14.3	47.3	42	55.9	10.2	2.7	40.9
				Weight at age (kg)			
Age class	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	0.005	0.004	0.005	0.005	0.005	0.005	0.005
1	0.012	0.011	0.011	0.01	0.011	0.01	0.009
2	0.027	0.027	0.028	0.028	0.027	0.028	0.028
3	0.046	0.047	0.048	0.047	0.046	0.046	0.046
4+	0.061	0.062	0.061	0.062	0.06	0.057	0.061
Age class	**Maturity at age**		Age class	**Natural mortality**			
0	0.07863309		0	0.45			
1	0.7669088		1	0.45			
2	0.9980806		2	0.45			
3	1		3	0.45			
4+	1		4+	0.45			
				Tunning parameters (MEDITS)			
Age class	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	0.98763066	0.32547841	0.71542121	0.34818368	0.58151751	2.49106938	0.09087769
1	8.35745246	4.17407313	4.5871268	1.60779257	14.0884189	6.58091453	0.6404755
2	2.19192715	2.14427471	1.52464883	0.66831594	6.84555265	5.59664485	0.12580226
3	0.14173455	0.97178209	0.24546964	0.09977672	0.52608953	7.5953E-05	0.03186625
4+	0.08140866	0.12189778	0.12348588	0.06894482	3.4299E-05	3.4299E-05	3.4299E-05

5.53.4.1.3. Results including sensitivity analyses

Tab. 5.53.4.1.3.1 Results of the XSA assessment. Estimated fishing mortality and summary table listing trends in recruitment at age 0, total and spawning stock biomass, landings, ratio between yield and SSB as well as mean fishing mortality over ages 0-3.

Table 8	Fishing mortality (F) at age							
YEAR	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**FBAR ****
AGE								
0	0.0574	0.0974	0.0854	0.087	0.0595	0.0615	0.1447	0.0886
1	1.3833	1.5526	2.1926	1.9511	1.5723	1.5899	2.1403	1.7675
2	1.4101	1.3287	1.2724	1.8	1.4799	0.8345	1.4833	1.2659
3	1.115	1.2141	1.2301	1.2836	0.9074	0.9687	1.4108	1.0956
+gp	1.115	1.2141	1.2301	1.2836	0.9074	0.9687	1.4108	
0 FBAR 0- 3	0.9915	1.0482	1.1951	1.2805	1.0048	0.8636	1.2948	
1								
Table 17	Summary	(with SOP correction)						
	Terminal Fs derived using XSA (With F shrinkage)							
	RECI	**TOTALBIC**	**TOTSPBIC**	**LANDINGS**	**YIELD/SSE**	**SOPCOFA**	**FBAR 0- 3**	
	Age 0							
2002	38696	1487	913	645	0.7062	2.2591	0.9915	
2003	61795	1582	887	647	0.7291	2.4141	1.0482	
2004	58006	759	422	347	0.8213	0.9359	1.1951	
2005	62513	747	384	316	0.8234	0.9887	1.2805	
2006	80014	870	422	320	0.7577	0.9683	1.0048	
2007	93908	1302	661	470	0.7113	1.1765	0.8636	
2008	91043	1385	766	638	0.8332	1.1521	1.2948	
Arith.								
Mean	69425	1162	637	483	0.7689		1.0969	
0 Units	(Thousands	(Tonnes)	(Tonnes)	(Tonnes)				

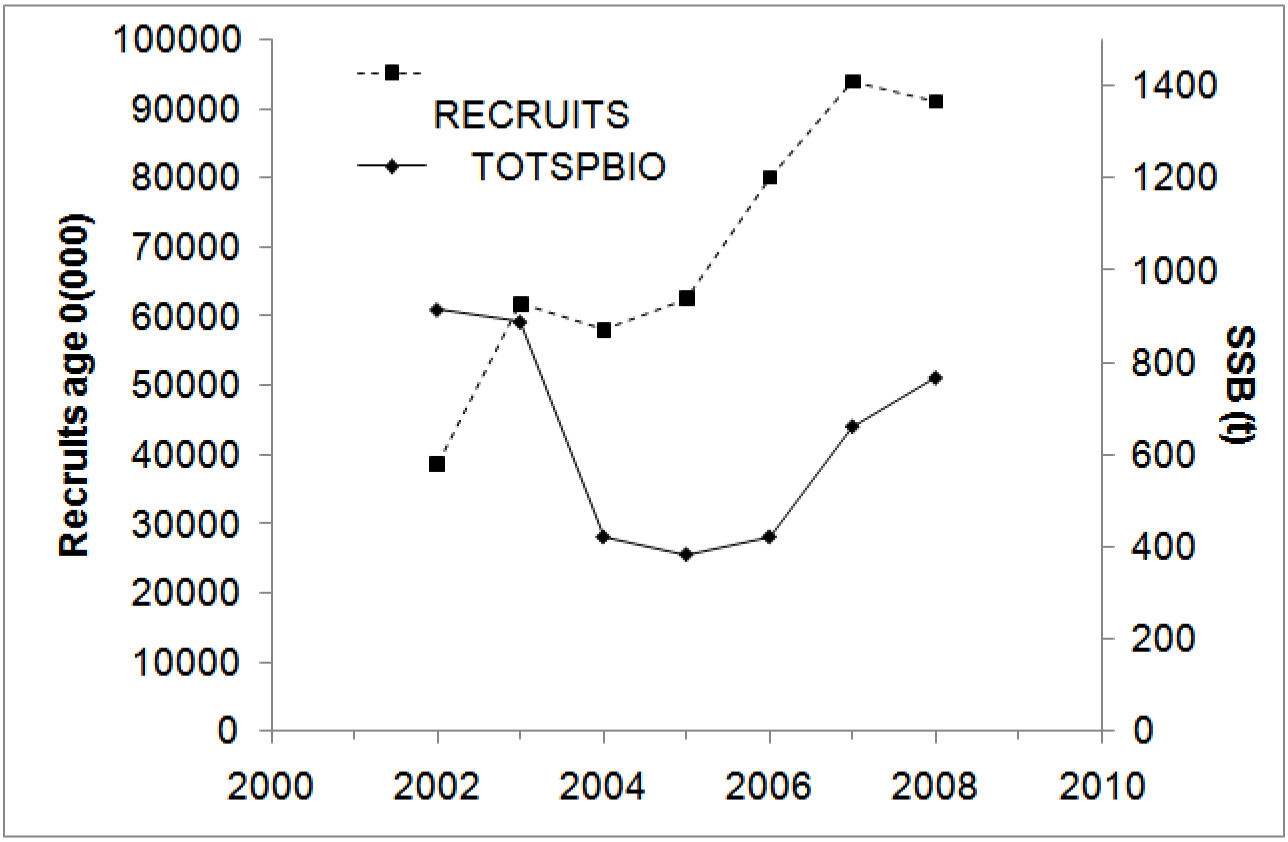


Fig. 5.53.4.1.3.1 Trends is spawning stock biomass (SSB) and recruitment as estimated by XSA.

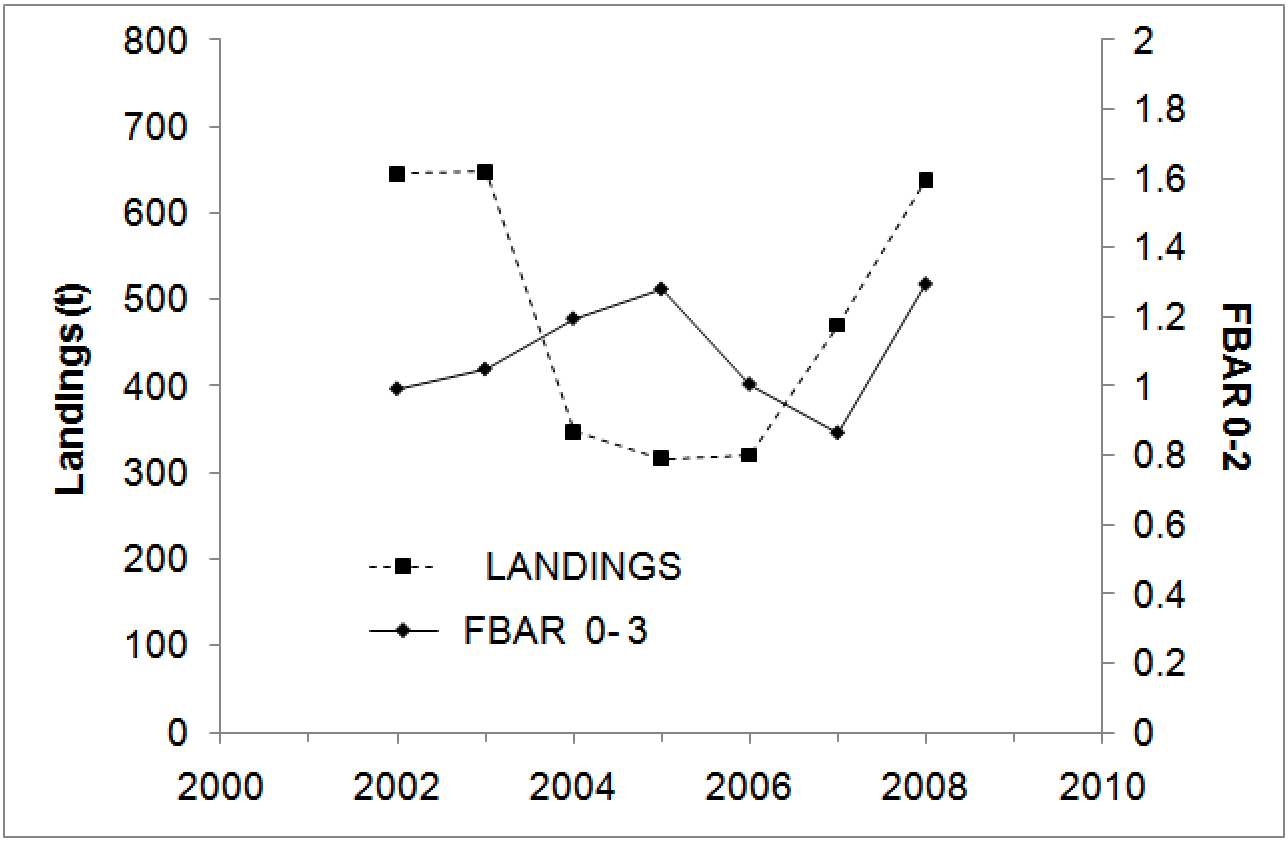


Fig. 5.53.4.1.3.2 Trends in landings and mean fishing mortality (FBAR) as estimated by XSA.

5.53.5. *Long term prediction*

5.53.5.1. Justification

No forecast analyses were conducted.

5.53.5.2. Input parameters

No forecast analyses were conducted.

5.53.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for red shrimp in GSA 06.

5.53.6. *Scientific advice*

5.53.6.1. Short term considerations

5.53.6.1.1. State of the spawning stock size

Since 2002, SSB, with an average for the whole period of 637 mt, declined rapidly from 2002 to 2004 reaching the lowest value (384 t) observed in 2002-2008 which represents a 25% of that observed in 2002. Thereafter, SSB is estimated to increase until 2008 almost to the level seen in the beginning of the assessed time period.

SGMED-10-02 notes that the MEDITS survey abundance index shows oscillations along the period, generally decreasing from 1996 to 2007 and largely increasing in 2008 and 2009. The large variation in the CPUE might be related to the fact that MEDITS survey is principally able to track recruitment or that the SSB is such low that the stock (and relative stock indices) is highly dependent to the incoming year classes. However, this would require further data and analysis.

SGMED-10-02 cannot evaluate the state of the spawning stock relative to reference points, as these have not been proposed or defined.

5.53.6.1.2. State of recruitment

Recruits (aged 0 individuals) were estimated to increase significantly from 2003 to 2007 and remain high in 2008.

5.53.6.1.3. State of exploitation

Mean fishing mortality from 2002 to 2008 varied without a clear trend between 0.8 and 1.3. The highest value is observed in 2008.

Due to the lack of proposed and agreed limit management reference point for exploitation consistent with high long term yields, SGMED-10-02 is unable to fully evaluate the state of exploitation.

5.54. Stock assessment of blue and red shrimp in GSA 10

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.54.1. Stock identification and biological features

5.54.1.1. Stock Identification

Recent studies based on microsatellite DNA analysis have evidenced genetic differences between the central-southern Tyrrhenian Sea (Sardinia and north Sicily) populations and north Tyrrhenian-Ligurian Sea and Algeria populations (AAVV, 2008, EU Project, Ref. Fish/2004/03-32). Given the preliminary state of these outcomes and lacking other specific analyses the stock of blue and red shrimp *Aristeus antennatus* was assumed in the boundaries of the whole GSA 10. This species and the giant red shrimp *Aristaeomorpha foliacea* are deep-water decapods characterised by seasonal variability and annual fluctuations of abundance (Spedicato *et al*., 1995), as reported for other geographical areas (e.g. Relini and Orsi Relini, 1987). The blue and red shrimp is mainly distributed beyond 500 m depth.

The depth factor appears to influence the sex ratio, which is generally dominated by the females (sex ratio ~0.8-0.9) at 500-700 m depth, as sexes are partially segregated into different bathymetric ranges (e.g. Sardà *et al.*, 2004). The spawning period extends from April to October-November with a peak in July-August (Spedicato *et al.*, 1995). Males are mature all year round. The smallest mature female observed in the area was 18 mm carapace length.

Considering the length of the spawning season, the recruitment has an almost continuous pattern, although there are no clear and well separated peaks of recruit abundance in the LFDs, because this fraction of the population is not fully available. Indeed, from Medits and Grund surveys, individuals less than 20 mm are in general about 2% and, according to the current literature knowledge on the growth pattern, they should already been older than 1 year (16 mm average length at 1 year; e.g. Orsi Relini and Relini, 1998).

In general, the length frequency distributions of the blue and red shrimp have a pattern with overlapping modes and poorly separable components. For the females a life span of 6-10 years was estimated. The structure of the sizes of *A. antennatus* is characterised by marked differences in growth between the sexes. The larger individuals are females.

According to the benthic bionomic classification of Pérès and Picard (1964) *P. longirostris*, *N. norvegicus* and red-shrimps typify the populations of slope and bathyal bottoms in the GSA 10. Depending on the depth and zone, this fauna is accompanied by characteristic bentic species as *Funiculina quadrangularis*, *Geryon longipes*, *Polycheles typhlops*, *Isidella elongata*, *Griphus vitreus*.

In the central-southern Tyrrhenian Sea the blue and red shrimp represents a specific target of deep-waters trawling fishery given its high economic value (Spedicato *et al.*, 1995).

5.54.1.2. Growth

In the central-southern Tyrrhenian the maximum carapace length (CL) observed in females and males was 65 mm and 39.7 mm (Spedicato *et al*., 1995). After estimates of VBGF obtained in the past, growth has been also recently re-assessed in the DCR framework and in the Red Shrimps project (AAVV, 2008) through the analysis of the LFDs. Given the difficulty to separate LFDs into normal components, the LFDs have been analysed according to the procedure first adopted in the Samed project (SAMED, 2002). Thus, an L_{max} (predicted maximum length; procedure implemented in FiSAT) value to be used as guess estimate of L_{∞} was computed. This value was then tuned with that obtained from the Powell and Wetherall approach, which gives also estimates of the Z/K ratio. According to the hypothesis of a slow growth pattern (Orsi Relini and

Relini, 1998) age 1 at a mean size of 16 mm was assumed and a first estimate of K derived from the ratio: average length at age 1/L∞. Thus also a first value of Z was obtained. These parameters were finally calibrated trough the Length Converted Catch Curve (LCCC) and the set giving the better determination coefficient was adopted: females CL_{∞}=66 mm, K=0.243, t_0= -0.2. Parameters of the length-weight relationship were a=0.8512, b=2.4 for females and a=0.9747, b=2.187 for males, for length expressed in cm.

5.54.1.3. Maturity

The maturity ogive was estimated from a maximum likelihood procedure considering as mature the individuals with maturity stage 2 and onwards (Fig. 5.54.1.3.1). The value of $CL_{m50\%}$ was 2.44 cm (±0.049 cm). However the fitting obtained was poor and seems to overestimates the length at first maturity.

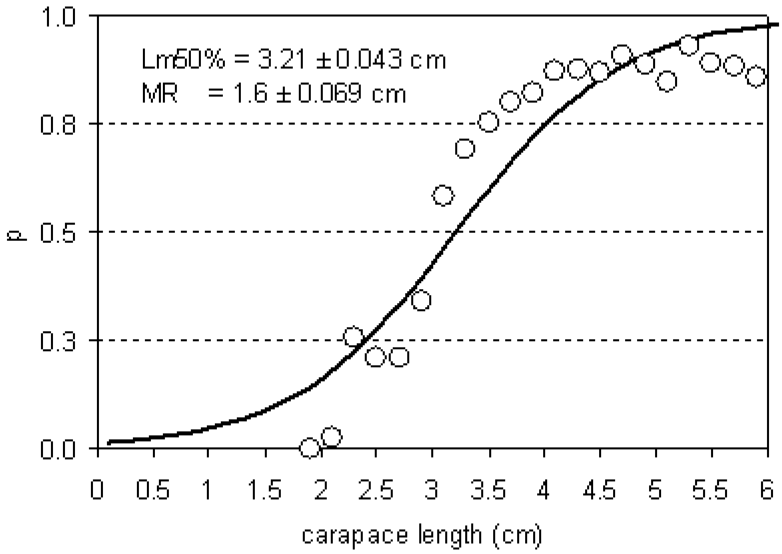


Fig. 5.54.1.3.1 Maturity ogive of blue and red shrimp in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio from DCR evidenced the prevalence of males in the first two size classes (1.8-2.0 cm) while from 2.4 cm onwards the proportion of females was dominant (Fig. 5.54.1.3.2).

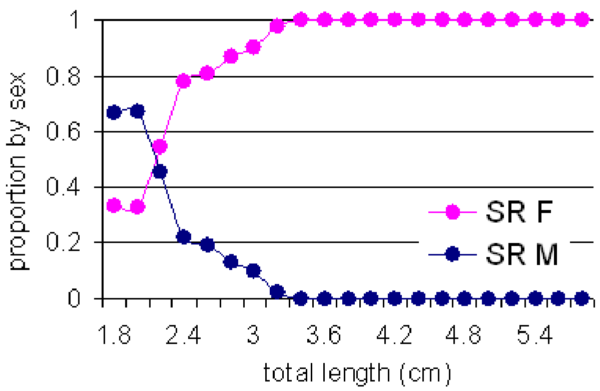


Fig. 5.54.1.3.2 Sex ratio over length.

5.54.2. Fisheries

5.54.2.1. General description of fisheries

The blue and red shrimp is only targeted by trawlers on fishing grounds located offshore 200 m depth, mainly southward Salerno Gulf. Catches from trawlers are from a depth range between 400 and 700 m depth and the blue and red shrimp occurs with *A. foliacea*, *P. longirostris* and *N. norvegicus*, *P. blennoides*, *M. merluccius*, depending on operative depth and area.

5.54.2.2. Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures, like the number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of the fishing fleet, the Italian fishing licenses have been fixed since the late 1980s. After 2000, in agreement with the European Common Fisheries Policy, a gradual decreasing of the fleet capacity is implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990. Two closed areas were also established in 2004 along the mainland, in front of Sorrento peninsula (Napoli Gulf) and Amantea (Calabrian coasts) although these protected area mainly cover the distribution of coastal species. Other measures on which the management regulations are based are technical measures (mesh size) and minimum landing sizes (EC reg. 1967/06). In the GSA 10 the fishing ban has not been mandatory and it has been adopted on a voluntary basis by the fleet.

5.54.2.3. Catches

5.54.2.3.1. Landings

Available landing data are from DCR regulations. Italian landings data for GSA 10 by major fishing gears which are listed in Tab. 5.54.2.3.1.1. After 2004, landings of the blue and red shrimp decreased. Most part of the landings is from trawlers. No 2009 data were submitted by the Italian authorities.

Tab. 5.54.2.3.1.1 Total landings (t) in the GSA10 2004-2008 as reported through the official DCF data call in 2010. No 2009 data were submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
ARA	10	ITA	GNS	DEMSP				0	2	0			
ARA	10	ITA	OTB	DWSP						6	2	2	
ARA	10	ITA	OTB	MDDWSP				120	62	46	37	21	
Sum								120	64	52	39	23	

5.54.2.3.2. Fishing effort

The trends in fishing effort by year and major gear type is listed in Tab. 5.54.2.3.2.1. No 2009 data were submitted by the Italian authorities.

Tab. 5.54.2.3.2.1 Trend in fishing effort (kW*days) in the GSA 10, 2004-2008 as reported through the official DCF data call in 2010. No 2009 data were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
10	ITA				VL0006				1347			
10	ITA				VL0612		84318	65385	32480	27509	24608	
10	ITA				VL1218		13612	27229	5986	18865	7513	
10	ITA	DRB	MOL		VL1218		10149	14848	23073	34394	21067	
10	ITA	FPO	DEMSP		VL0006				5938			
10	ITA	FPO	DEMSP		VL0612			14239				
10	ITA	GND	SPF		VL0006					1521	1437	
10	ITA	GND	SPF		VL0612			4316	8070		15882	
10	ITA	GND	SPF		VL1218		1895	3429			8303	
10	ITA	GNS	DEMSP		VL0006				221	9122	6623	
10	ITA	GNS	DEMSP		VL0612		45875	229661	74360	139622	124448	
10	ITA	GNS	DEMSP		VL1218						18180	
10	ITA	GTR	DEMSP		VL0006				30332	16894	13248	
10	ITA	GTR	DEMSP		VL0612		86781	82711	191382	140832	172542	
10	ITA	GTR	DEMSP		VL1218		12514	21108	28430	16110	17755	
10	ITA	LHP-LHM	CEP		VL0006				2369	3463	1018	
10	ITA	LHP-LHM	CEP		VL0612		1239	2450	4458	15003		
10	ITA	LHP-LHM	FINF		VL1218		716	1013				
10	ITA	LLD	LPF		VL0006						1968	
10	ITA	LLD	LPF		VL0612						2138	
10	ITA	LLD	LPF		VL1218		4627		10673	10266	14174	
10	ITA	LLS	DEMF		VL0006				11628	3467	2996	
10	ITA	LLS	DEMF		VL0612		104125	101629	61456	56957	26693	
10	ITA	LLS	DEMF		VL1218		13376	27517	61348	52670	32330	
10	ITA	OTB	DEMSP		VL0612		16454					
10	ITA	OTB	DEMSP		VL1218		44743		102448	127832	98014	
10	ITA	OTB	DEMSP		VL1824		90104		224283	204068	242063	
10	ITA	OTB	DWSP		VL1824						2388	
10	ITA	OTB	MDDWSP		VL1218		130612	247796	142430	169560	83026	
10	ITA	OTB	MDDWSP		VL1824		97221	239878	71963	86844	55526	
10	ITA	PS	LPF		VL0612					5291		
10	ITA	PS	LPF		VL1218					4926		
10	ITA	PS	SPF		VL0006				7337			
10	ITA	PS	SPF		VL0612		4653	27986				
10	ITA	PS	SPF		VL1218		49995	54113	68805	73452	20179	
10	ITA	SB-SV	DEMSP		VL0006				0			
10	ITA	SB-SV	DEMSP		VL0612		12786					
10	ITA	SB-SV	DEMSP		VL1218						8756	

5.54.3. Scientific surveys

5.54.3.1. Medits

5.54.3.1.1. Methods

According to the MEDITS protocol (Bertrand *et al*., 2002), trawl surveys were carried out yearly (May-July), applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed.

Based on the DCR data call, abundance and biomass indices were calculated. In GSA 10 the following number of hauls were reported per depth stratum (Tab. 5.54.3.1.1.1).

Tab. 5.54.3.1.1.1 Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	9	10	10	10	10	10	10	10	9	9	9	9	9	9	9	9
GSA10_050-100	12	12	12	12	12	12	12	12	10	10	10	10	10	10	10	10
GSA10_100-200	20	20	20	20	20	20	20	20	17	17	17	17	17	17	17	17
GSA10_200-500	26	27	26	26	27	26	26	28	22	22	22	22	22	22	22	22
GSA10_500-800	31	30	31	31	31	30	31	29	26	27	26	26	26	26	26	26

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Only hauls considered as valid were used in the analysis including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

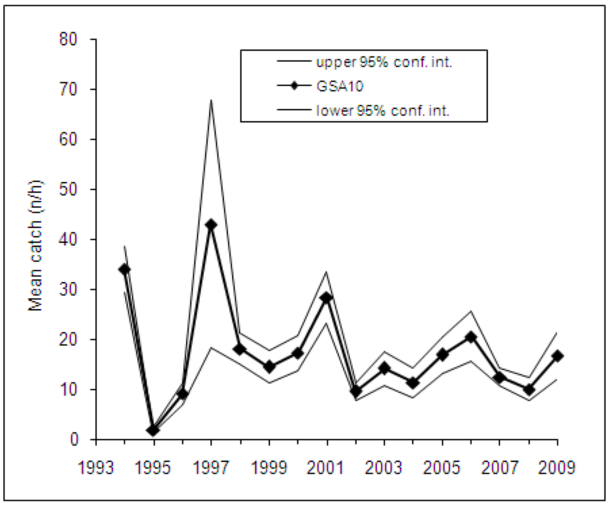
5.54.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.54.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the red shrimp in GSA 10 was derived from the international survey Medits. Figure 5.54.3.1.3.1 displays the estimated trend in blue and red shrimp abundance and biomass in GSA 10.

The estimated abundance and biomass indices varied without a clear trend during 1994-2009.



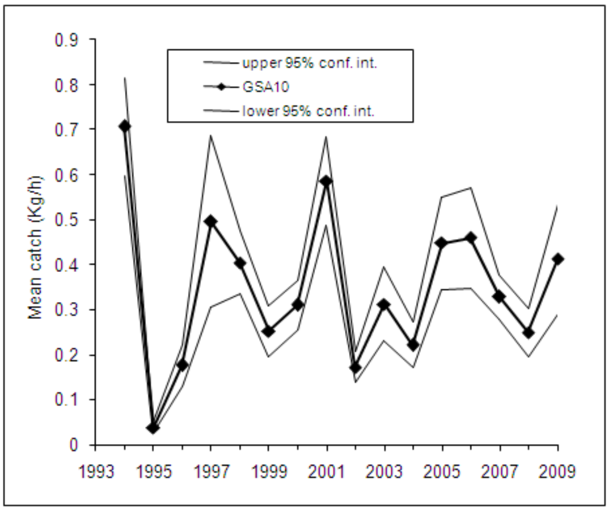


Fig. 5.54.3.1.3.1 Abundance and biomass indices of red shrimp in GSA 10.

5.54.3.1.4. Trends in abundance by length or age

The following Fig. 5.54.3.1.4.1 and 2 display the stratified abundance indices for GSA 10 in 1994-2009.

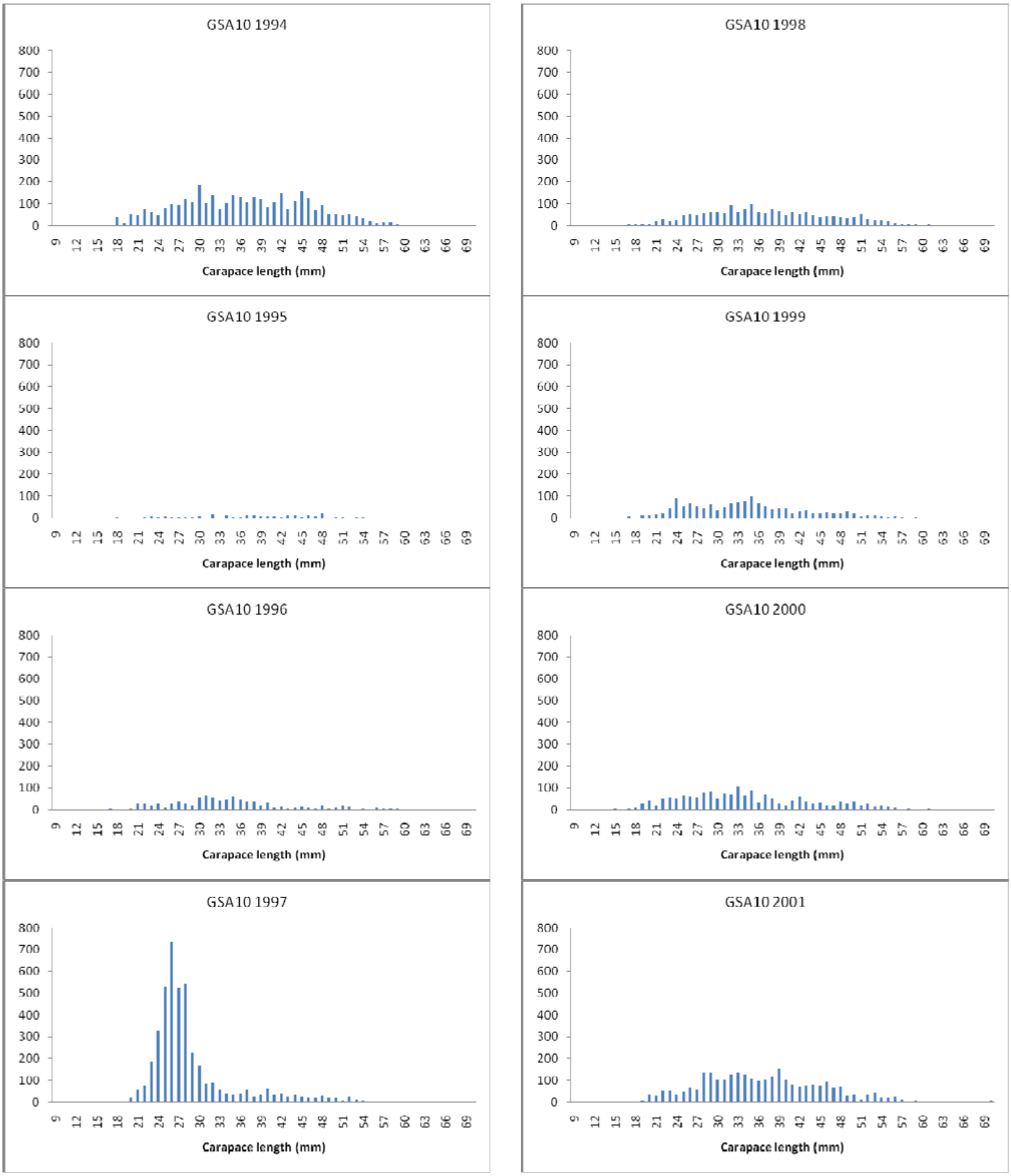


Fig. 5.54.3.1.4.1 Stratified abundance indices by size, 1994-2001.

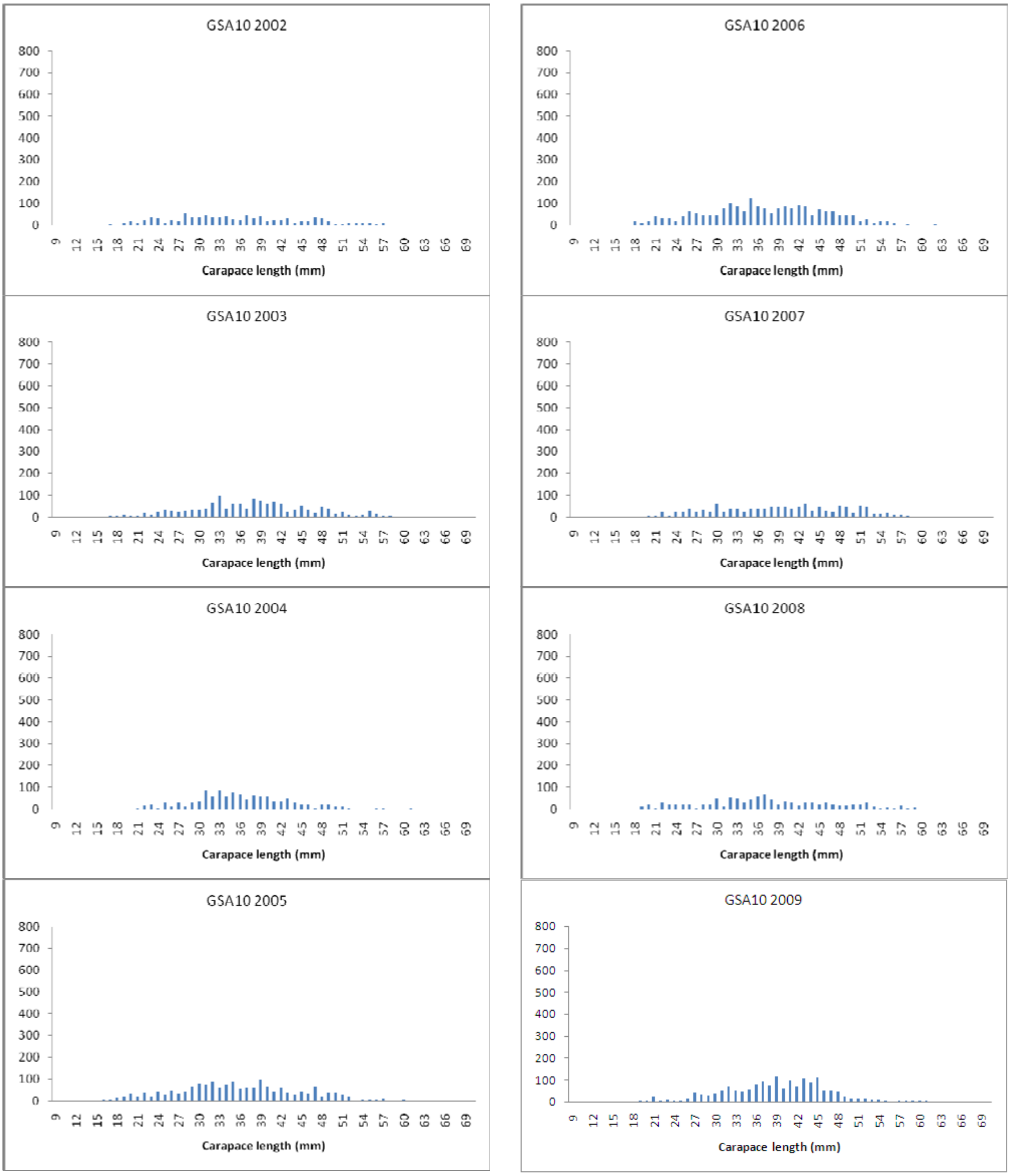


Fig. 5.54.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.54.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.54.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.54.3.2. GRUND

5.54.3.2.1. Methods

Since 2003 Grund surveys (Relini, 2000) was conducted using the same sampler (vessel and gear) in the whole GSA. Sampling scheme, stratification and protocols were similar as in Medits. All the abundance and biomass data were standardised to the square kilometre, using the swept area method.

5.54.3.2.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.54.3.2.3. Trends in abundance and biomass

Trends derived from the GRUND surveys are shown in Fig. 5.54.3.2.3.1. Abundance and biomass indices show some fluctuations with peaks in different years from Medits. Higher values were recorded in 1996 and 2005.

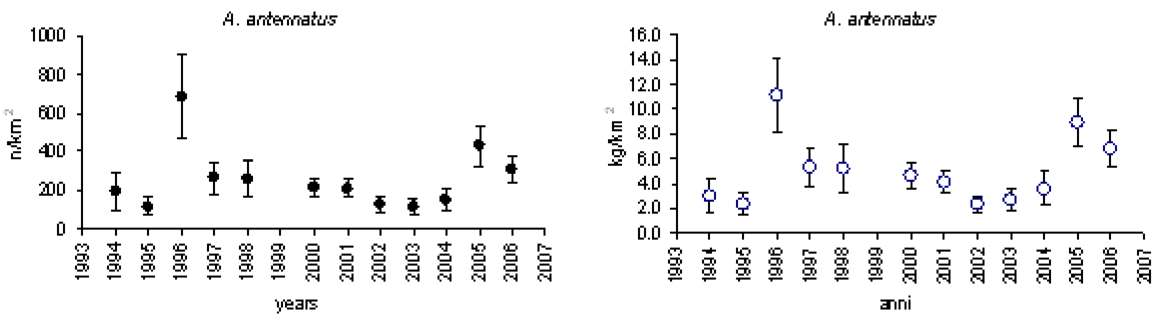


Fig. 5.54.3.2.3.1. Abundance and biomass indices of blue and red shrimp in GSA 10 (bars indicate standard deviations) derived from Grund surveys.

5.54.3.2.4. Trends in abundance by length or age

No annual figures of length compositions were constructed.

A positive trend in the mean length was observed in Medits survey (Fig. 5.54.3.2.4.1), while no trend at the third quantile lengths was observed in the length structures of Grund time series from 1994 to 2006 (Fig. 5.54.3.2.4.2).

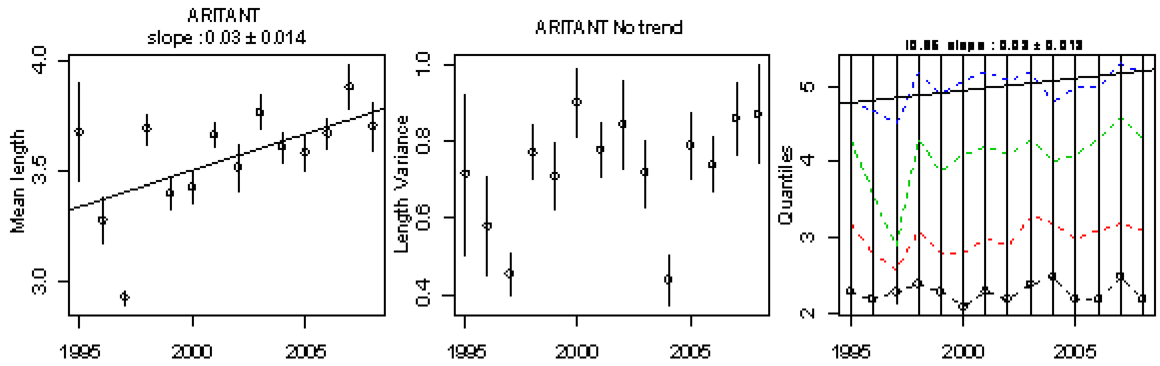


Fig. 5.54.3.2.4.1 Mean length, variance and quantiles derived from the Medits length compositions in 1995-2008.

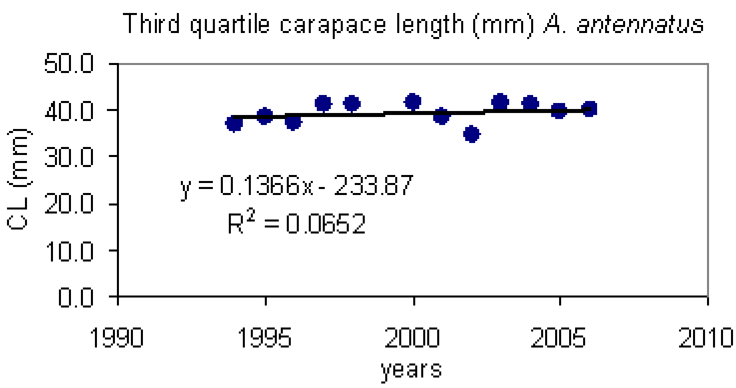


Fig. 5.54.3.2.4.2 III Quantile derived from the GRUND length structures in 1994-2006.

5.54.3.2.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.54.3.2.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.54.4. Assessment of historic stock parameters

No analytical assessment was performed.

5.54.5. Long term prediction

5.54.5.1. Justification

No forecast analyses were conducted.

5.54.5.2. Input parameters

No forecast analyses were conducted.

5.54.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a short term prediction of catch and stock biomass for blue and red shrimp in GSA 10.

5.54.6. Scientific advice

5.54.6.1. Short term considerations

5.54.6.1.1. State of the spawning stock size

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the spawning stock.

5.54.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of recruitment in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.54.6.1.3. State of exploitation

In the absence of proposed and agreed limit management reference points consitstent with high long term yields SGMED-10-02 is unable to fully evaluate the state of the exploitation of the stock.

5.55. Stock assessment of blue and red shrimp in GSA 11

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.55.1. Stock identification and biological features

5.55.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.55.1.2. Growth

No information was documented during SGMED-10-02.

5.55.1.3. Maturity

No information was documented during SGMED-10-02.

5.55.2. Fisheries

5.55.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.55.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.55.2.3. Catches

5.55.2.3.1. Landings

Tab. 5.55.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. The landings were mainly taken by demersal otter trawls.

Tab. 5.55.2.3.1.1 Annual landings (t) by fishing technique in GSA 11 as reported through the official DCF data call in 2010. The Italian authorities did not submit 2009 landings.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
ARA	11	ITA	OTB	DWSP								20	
ARA	11	ITA	OTB	MDDWSP				174	299	225	125	92	
Sum								174	299	225	125	112	

5.55.2.3.2. Discards

According to information available to the SGMED-10-02 no catches of *Aristeus antennatus* were discarded by the Italian fleet.

5.55.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.55.2.3.3.1.

Tab. 5.55.2.3.3.1 Trends in annual fishing effort (kW*days) by fishing technique deployed in GSA 11 as reported through the official DCF data call in 2010, 2004-2008. The Italian authorities did not submit 2009 data.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
11	ITA	FPO	DEMSP		VL0006					8227	1107	
11	ITA	FPO	DEMSP		VL0612				13379	69823	43856	
11	ITA	FPO	DEMSP		VL1218					16165	4731	
11	ITA	FYK	DEMSP		VL0006						0	
11	ITA	GNS	DEMSP		VL0006				0	3950	2439	
11	ITA	GNS	DEMSP		VL0612		22701	54787	5413	44336	35469	
11	ITA	GNS	DEMSP		VL1218		5248	39173	9568	7130	19593	
11	ITA	GTR	DEMSP		VL0006				5465	5988	4328	
11	ITA	GTR	DEMSP		VL0612			38115	82656	176487	116844	
11	ITA	GTR	DEMSP		VL1218		1814	54332	19069	75188	64023	
11	ITA	LHP-LHM	CEP		VL0006					4305	1131	
11	ITA	LHP-LHM	CEP		VL0612		3065		2611	9764	3353	
11	ITA	LHP-LHM	CEP		VL1218					12237	4371	
11	ITA	LHP-LHM	FINF		VL0612						3480	
11	ITA	LLD	LPF		VL1218			6694				
11	ITA	LLD	LPF		VL2440					1975		
11	ITA	LLS	DEMF		VL0006				228	2263	0	
11	ITA	LLS	DEMF		VL0612		50046	61709	4253	76836	29234	
11	ITA	LLS	DEMF		VL1218		3499	34499	20040	43290	25525	
11	ITA	LLS	DEMF		VL2440					13170		
11	ITA	OTB	DEMSP		VL1218		75568	77835	108842		95470	
11	ITA	OTB	DEMSP		VL1824						66067	
11	ITA	OTB	DEMSP		VL2440						22082	
11	ITA	OTB	MDDWSP		VL1218					152444	8561	
11	ITA	OTB	MDDWSP		VL1824		115969	188926	141391	195889	35045	
11	ITA	OTB	MDDWSP		VL2440		213246	234872	190232	187054	126564	
11	ITA	PS	SPF		VL1218		4109					

5.55.3. Scientific surveys

5.55.3.1. Medits

5.55.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 11 the following number of hauls was reported per depth stratum (s. Tab. 5.55.3.1.1.1).

Tab. 5.55.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18
GSA11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20
GSA11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24
GSA11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19
GSA11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.55.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.55.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the blue and red shrimp in GSA 11 was derived from the international survey Medits. Figure 5.55.3.1.3.1 displays the estimated trend in blue and red shrimp abundance and biomass in GSA 11.

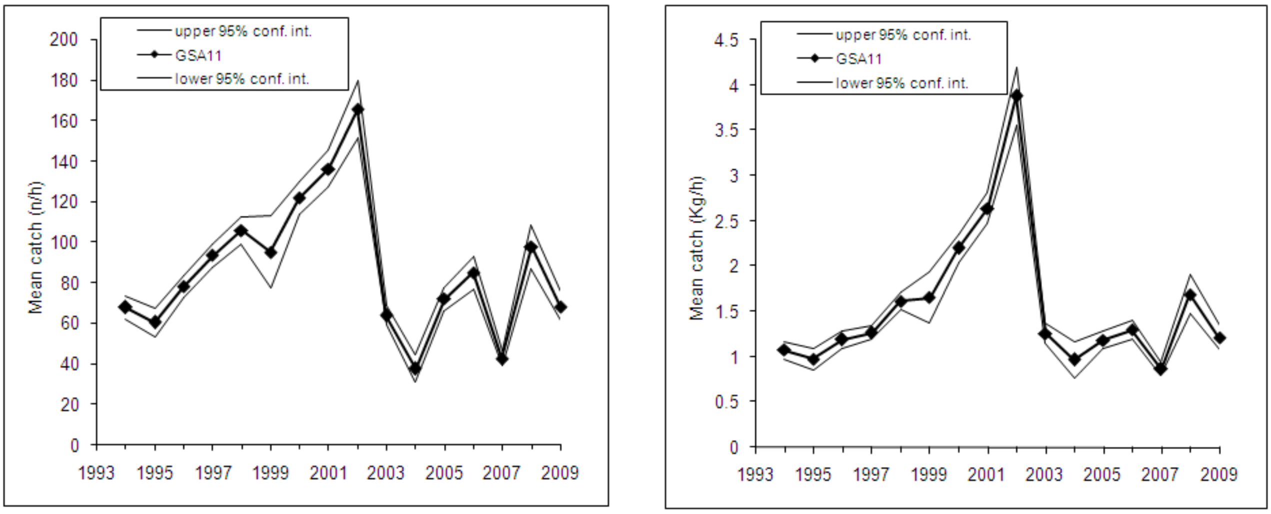


Fig. 5.55.3.1.3.1 Abundance and biomass indices of blue and red shrimp in GSA 11.

5.55.3.1.4. Trends in abundance by length or age

The following Fig. 5.55.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2009.

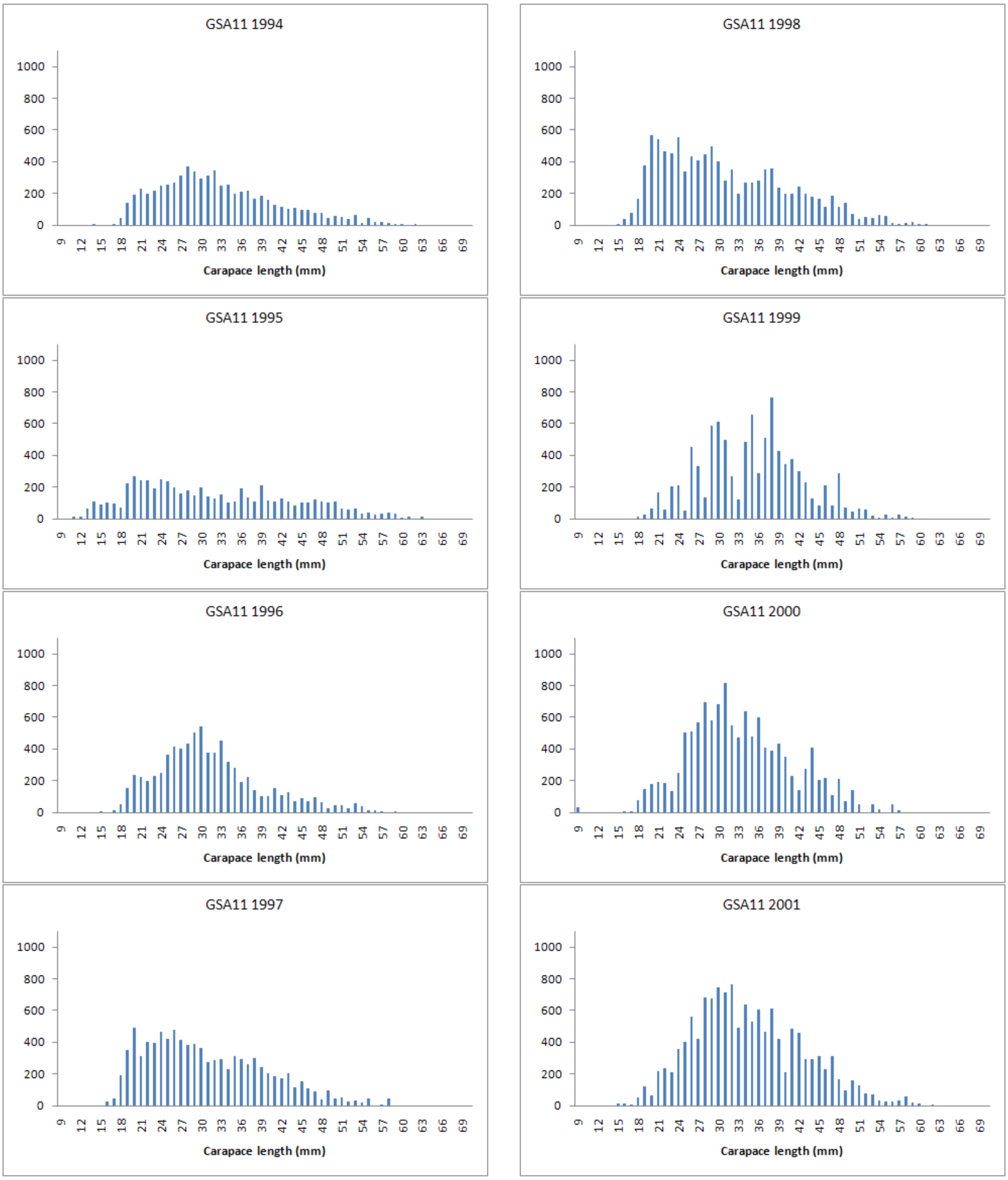


Fig. 5.55.3.1.4.1 Stratified abundance indices by size, 1994-2001.

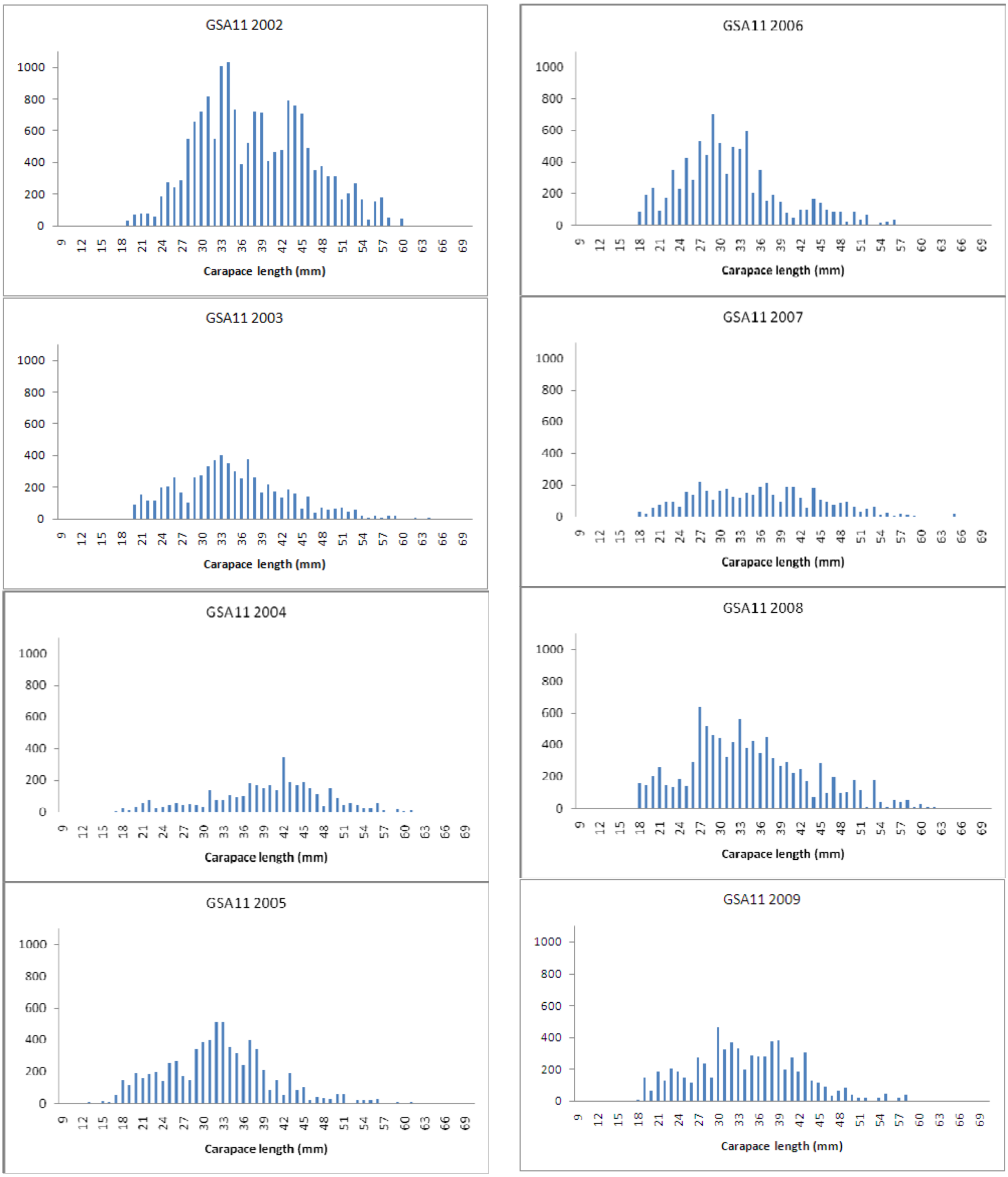


Fig. 5.55.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.55.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.55.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.55.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.55.5. Long term prediction

5.55.5.1. Justification

No forecast analyses were conducted.

5.55.5.2. Input parameters

No forecast analyses were conducted.

5.55.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for blue and red shrimp in GSA 11.

5.55.6. Scientific advice

5.55.6.1. Short term considerations

5.55.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.55.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.55.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation given the preliminary state of the data and analyses.

5.56. Stock assessment of blue and red shrimp in GSA 16

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.56.1. Stock identification and biological features

5.56.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.56.1.2. Growth

No information was documented during SGMED-10-02.

5.56.1.3. Maturity

No information was documented during SGMED-10-02.

5.56.2. Fisheries

5.56.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.56.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.56.2.3. Catches

5.56.2.3.1. Landings

Tab. 5.56.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. The landings were taken by demersal otter trawls.

Tab. 5.56.2.3.1.1 Annual landings (t) by fishing technique in GSA 16. Data are submitted through the official DCF data call in 2010. The Italian authorities did not submit 2009 data.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
ARA	16	ITA	OTB	DWSP					3			105	
ARA	16	ITA	OTB	MDDWSP				182	137	163	164	30	
Sum								182	140	163	164	135	

5.56.2.3.2. Discards

According to information available to the SGMED-10-02 no catches of *Aristeus antennatus* were discarded by the Italian fleet.

5.56.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.56.2.3.3.1.

Tab. 5.56.2.3.3.1 Trends in annual fishing effort (kw*days) by fishing technique deployed in GSA 16, 2004-2008. No data for 2009 were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
16	ITA				VL0612			3886			417	
16	ITA	GTR	DEMSP		VL0006				8548	9979	12285	
16	ITA	GTR	DEMSP		VL0612		164944	178522	76073	103953	103352	
16	ITA	GTR	DEMSP		VL1218		25926	7720	23894	18868	8189	
16	ITA	GTR	DEMSP		VL1824			1420				
16	ITA	LHP-LHM	CEP		VL0006				525	1162		
16	ITA	LHP-LHM	FINF		VL0612		16931	16553	14973	15019	21934	
16	ITA	LHP-LHM	FINF		VL1218		641					
16	ITA	LLD	LPF		VL1218		12401	3900	2924	3435	16936	
16	ITA	LLD	LPF		VL1824		36304	5756	1029	78320	12919	
16	ITA	LLS	DEMF		VL0006				1022	3942	1394	
16	ITA	LLS	DEMF		VL0612		26733	58661	12698	57631	9512	
16	ITA	LLS	DEMF		VL1218		21984	1640	3115	62773	18439	
16	ITA	LLS	DEMF		VL1824		1870					
16	ITA	OTB	DEMSP		VL1218		210042	238629	272220		263191	
16	ITA	OTB	DEMSP		VL1824		54367	13425			397440	
16	ITA	OTB	DEMSP		VL2440						693213	
16	ITA	OTB	DWSP		VL1824						15246	
16	ITA	OTB	DWSP		VL2440						41113	
16	ITA	OTB	MDDWSP		VL1218					285378	4336	
16	ITA	OTB	MDDWSP		VL1824		377936	418914	434834	549867	93949	
16	ITA	OTB	MDDWSP		VL2440		1116269	1161841	442196	1484331	225904	
16	ITA	OTM	MDPSP		VL1824				21611	26555	41792	
16	ITA	OTM	MDPSP		VL2440		5306		9096			
16	ITA	PS	LPF		VL1824						9763	
16	ITA	PS	SPF		VL0006						397	
16	ITA	PS	SPF		VL0612			8471		670	3127	
16	ITA	PS	SPF		VL1218		1772	1997	1355		2354	
16	ITA	PS	SPF		VL1824		17339	12429	7349	39307	11625	
16	ITA	PTM	SPF		VL1824			19612	72116	107330	38857	

5.56.3. Scientific surveys

5.56.3.1. Medits

5.56.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 16 the following number of hauls was reported per depth stratum (s. Tab. 5.56.3.1.1.1).

Tab. 5.56.3.1.1.1. Number of hauls per year and depth stratum in GSA 16, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA16_010-050	4	4	4	4	4	4	4	4	7	7	7	10	10	11	11	11
GSA16_050-100	9	8	8	8	8	8	7	8	11	12	12	20	22	23	23	23
GSA16_100-200	4	4	4	4	5	5	6	5	11	10	11	20	19	21	21	21
GSA16_200-500	10	11	11	12	11	11	11	11	19	18	26	37	31	27	27	27
GSA16_500-800	10	14	14	13	14	14	14	14	20	20	21	33	33	38	38	38

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai) / A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

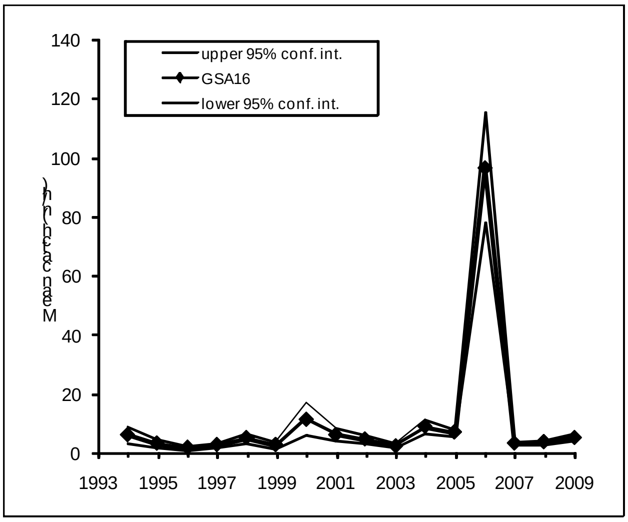
Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.56.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.56.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the blue and red shrimp in GSA 16 was derived from the international survey Medits. Figure 5.56.3.1.3.1 displays the estimated trend in blue and red shrimp abundance and biomass in GSA 16.



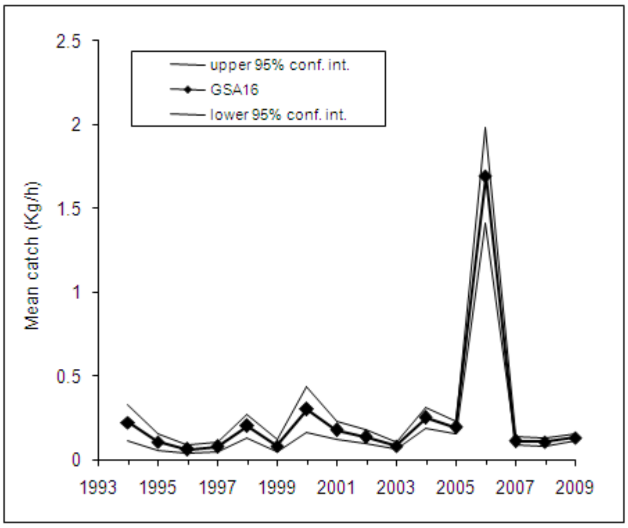


Fig. 5.56.3.1.3.1 Abundance and biomass indices of blue and red shrimp in GSA 16.

5.56.3.1.4. Trends in abundance by length or age

The following Fig. 5.56.3.1.4.1 and 2 display the stratified abundance indices of GSA 16 in 1994-2009.

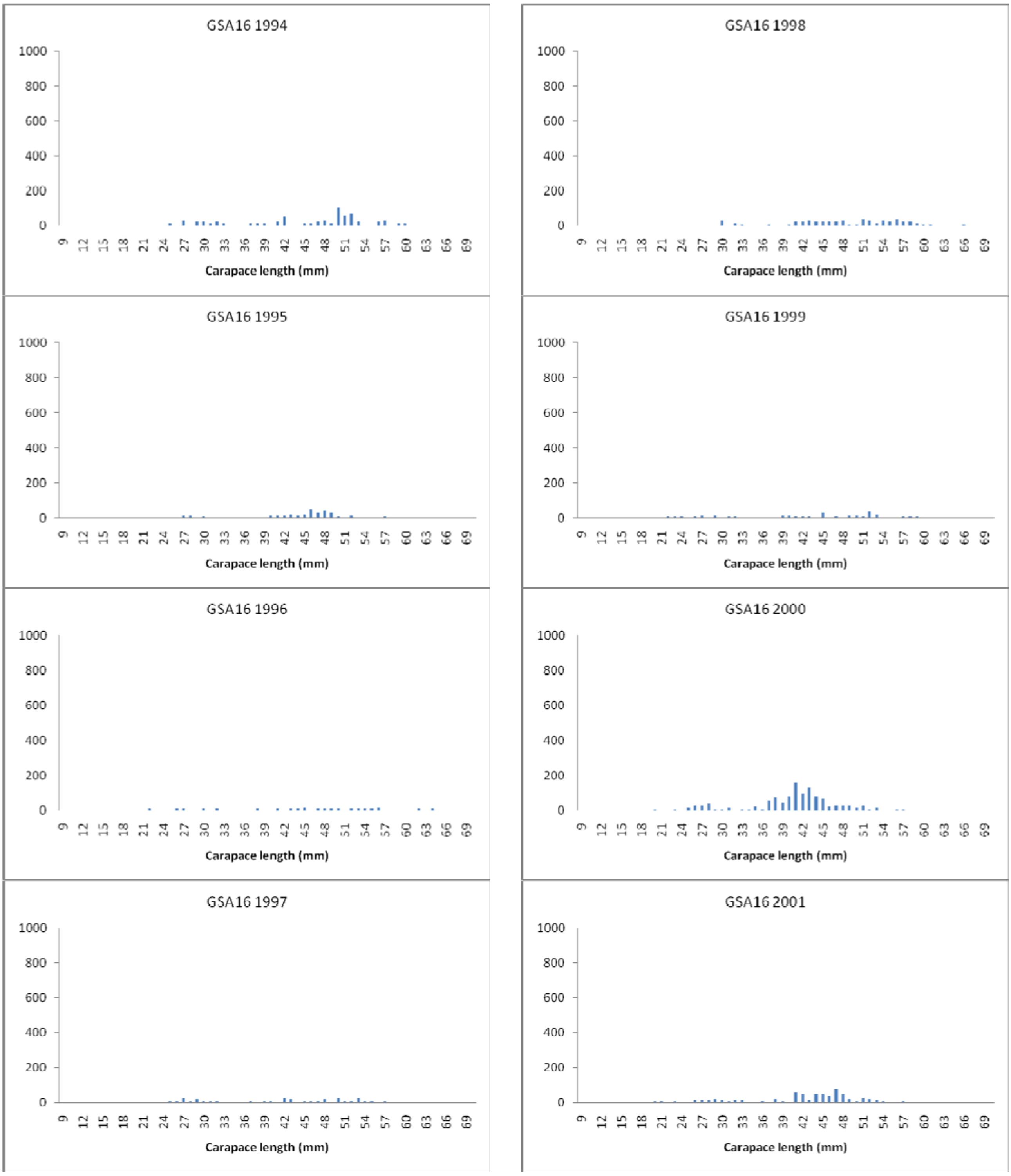


Fig. 5.56.3.1.4.1 Stratified abundance indices by size, 1994-2001.

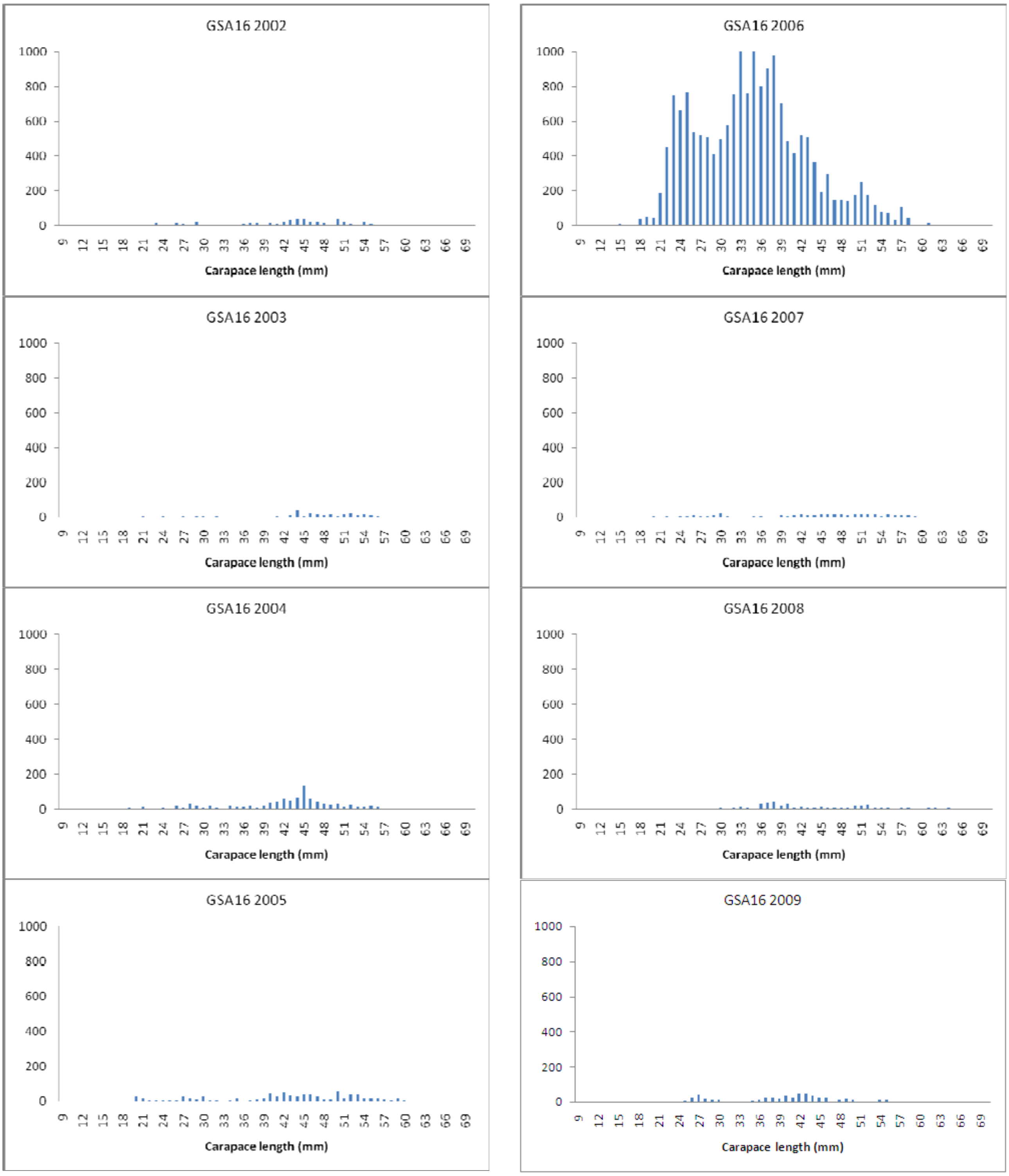


Fig. 5.56.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.56.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.56.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.56.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.56.5. Long term prediction

5.56.5.1. Justification

No forecast analyses were conducted.

5.56.5.2. Input parameters

No forecast analyses were conducted.

5.56.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for blue and red shrimp in GSA 16.

5.56.6. Scientific advice

5.56.6.1. Short term considerations

5.56.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.56.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.56.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation given the preliminary state of the data and analyses.

5.57. Stock assessment of giant red shrimp in GSA 10

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.57.1. Stock identification and biological features

5.57.1.1. Stock Identification

The stock of giant red shrimp, *Aristaeomorpha foliacea* was assumed in the boundaries of the whole GSA10, lacking specific information on stock identification. This species and the blue-red shrimp, *Aristeus antennatus*, are deep-water decapods characterised by seasonal variability and annual fluctuations of abundance (Spedicato *et al.*, 1994), as reported for different geographical areas (e.g. Relini and Orsi Relini, 1987). The giant red shrimp *A. foliacea* is distributed beyond 350 m depth, but mainly in water deeper than 500 m. Generally mean length estimated using trawl survey data varies remarkably with depth, for the whole population and the two sexes, increasing at deeper waters.

In the recent years *A. foliacea* is ranked among the more abundant species (in number and weight) in the trawl survey catches. Higher biomass indices occur particularly southwards the Gulf of Naples (Spedicato *et al.*, 1994).

This species has a discrete recruitment pattern and during spring trawl surveys (Medits) a recruitment pulse is observed. Since the reproduction takes place in the late spring-summer, recruits could be attributed to the spawning events of the previous year (Spedicato *et al.*, 1999). *A. foliacea* is considered fully recruited to grounds at about 24 mm CL (from SAMED, 2002). Recently a study at Mediterranean scale, using Medits data from 1994 to 2004, has evidenced that the higher abundance indices of recruits were observed in the central-southern Tyrrhenian Sea (AAVV, 2008).

In general the length frequency distributions of the giant red shrimp have a polymodal pattern, with 4-5 components for females (the modes of adults are less defined) and 2-3 components for the males. For the females a life span of 6-8 years was estimated. The structure of the sizes of *A. foliacea* is characterised by marked differences in growth between the sexes. The larger individuals are females and inhabit deeper waters.

Sex ratio values of about 0.5 shows that males and females are not segregated into different bathymetric ranges (Spedicato *et al*., 1994). The reproduction period extends from May to September, with a peak in the summer (July-August) (Spedicato *et al.*, 1999). Mature males have been observed all year round.

According to the benthic bionomic classification of Pérès and Picard (1964) *P. longirostris*, *N. norvegicus* and red-shrimps typify the populations of slope and bathyal bottoms in the GSA 10. Depending on the depth and zone, this fauna is accompanied by characteristic benthic species as *Funiculina quadrangularis*, *Geryon longipes*, *Polycheles typhlops*, *Isidella elongata*, *Griphus vitreus*.

In the central-southern Tyrrhenian Sea the giant red shrimp represents a specific target of the deep-waters trawling fishery given its high economic value (Spedicato *et al.*, 1994).

5.57.1.2. Growth

Estimates of the growth pattern of the giant red shrimp in the GSA 10 were previously obtained using Grund length frequency distributions from 1991 to 1995 and methods as Elefan and Batthacharya for the analysis of LFDs. Parameters of females were as follows: CL_∞=73.24 mm; K=0.483; t_0= -0.435 (Spedicato *et al.*, 1998). In the Samed project (SAMED, 2002) and using the Medits data from 1994 to 1999 a new set of parameters was estimated for the Tyrrhenian Sea down the Strait of Messina (females: CL_∞=73 mm; K=0.44; t_0= -0.05;

males: CL_{∞}=48 mm; K=0.59; t_0= -0.2). The observed maximum carapace length of females and males were 72 and 46 mm respectively.

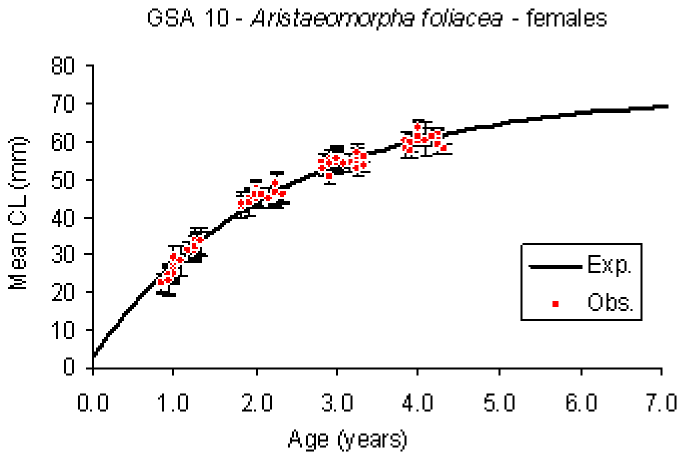
Growth has been also studied in the DCR framework and in the Red Shrimps project (AAVV, 2008) through the analysis of the LFDs and the separation of modal components. These estimates have been done using both Medits and Grund average length at estimated age, where age was set according to the date of each survey with a birthday on 1st July. Table 5.57.1.2.1 reports estimated ages, mean carapace lengths with relative standard deviations for females.

The following estimates of von Bertalanffy growth parameters for each sex were obtained from average length at age using an iterative non-liner procedure that minimises the sum of the square differences between observed and expected values and fixing the asymptotic length on the basis of the observed maximum values: females CL_{∞}=72.5 mm, K=0.438, t_0= -0.1; males: CL_{∞}=44 cm, K=0. 5, t_0= -0.1. These estimates are more accurate, although very close to those previously obtained.

Parameters of the length-weight relationship were a=0.54, b=2.71 for females and a=0.48, b=2.81 for males, for length expressed in cm.

Tab. 5.57.1.2.1 Estimated age, mean length of modal components of the LFD of Medits and Grund survey and relative standard deviations.

putative age	mean CL	st. dev.	putative age	mean CL	st. dev.	putative age	mean CL	st. dev.
0.8	21.9	2.29	2.0	45.5	2.58	3.1	54.3	1.01
0.8	22.5	2.36	2.0	47.5	2.05	3.2	54.5	2.11
0.9	23.0	3.38	2.0	44.9	1.8	3.2	53.5	1.33
0.9	24.6	2.78	2.0	46.7	3.06	3.2	55.3	1.52
0.9	23.0	3.75	2.0	45.9	3.76	3.2	57.0	1.53
1.0	26.6	2.96	2.1	46.2	1.85	3.2	57.2	2.1
1.0	25.0	3.16	2.2	45.1	2.59	3.2	54.3	2.23
1.0	26.0	1.95	2.2	46.6	1.55	3.2	53.5	1.71
1.0	24.8	2.26	2.2	49.2	2.23	3.2	52.9	1.97
1.0	29.1	2.79	2.2	45.6	2.98	3.3	56.0	1.47
1.1	28.2	3.82	2.2	49.1	3.31	3.3	53.6	1.25
1.2	31.0	2.58	2.2	45.8	2.3	3.8	60.3	2.46
1.2	33.3	2.68	2.2	45.9	2.62	3.8	57.9	2.14
1.2	32.8	2.37	2.2	46.6	1.98	3.9	60.0	2.38
1.2	33.4	2.65	2.3	46.1	1.8	3.9	57.6	2.15
1.2	33.7	3.05	2.3	46.2	2.39	4.0	63.1	2.54
1.2	31.1	2.66	2.8	54.7	2.38	4.0	60.3	1.55
1.2	32.1	3.55	2.8	52.6	1.84	4.0	63.8	1.3
1.2	32.0	2.81	2.9	55.0	3.16	4.0	61.1	2.35
1.3	32.9	3.07	2.9	54.0	2.05	4.1	60.5	4.56
1.3	33.5	3.16	2.9	50.9	1.81	4.2	61.3	2.35
1.8	42.6	2.77	3.0	54.8	3.05	4.2	62.0	1.14
1.8	43.8	2.42	3.0	54.9	2.74	4.2	60.4	3.37
1.9	44.4	2.38	3.0	55.7	2.9	4.2	58.8	2.05
1.9	45.2	2.53	3.0	54.8	3.53	4.2	59.6	1.03
1.9	43.8	3.6	3.0	55.6	3.18	4.3	57.8	1.37



	females	males
CL_{∞} (mm)=	72.5	44
k/year=	0.438	0.5
t_0(year)=	-0.10	-0.1

Fig. 5.57.1.2.1 V. Bertalanffy growth functions and parameters for female of giant red shrimp in the GSA 10. Used data are those reported in the Tab. 5.57.1.2.1.

5.57.1.3. Maturity

The maturity ogive (Fig. 5.57.1.3.1) was obtained from a maximum likelihood procedure applied grouping as mature individuals belonging to the maturity stage 2b (according to the Medits maturity scale) and onwards. The fitting of the curve was fairly good, however the estimates of the size at first maturity $L_{m50\%}$ (3.5 cm ±0.023 cm) and the maturity range (0.36 cm ±0.020 cm) seem underestimated if compared with literature values (average of the smallest females in the GSA is 34 mm CL; 39.6 mm carapace length according to Ragonese & Bianchini, 1995).

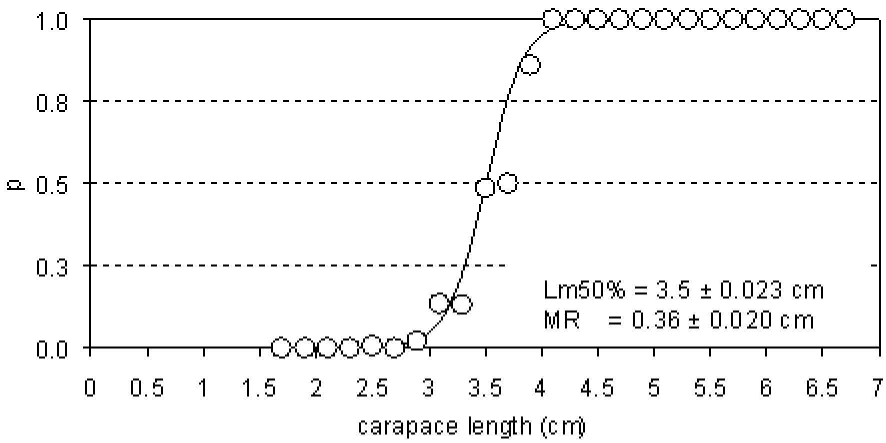


Fig. 5.57.1.3.1 Maturity ogive and proportions of mature female of giant red shrimp in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio from DCR evidenced the prevalence of males in the size class from 3.4 to 3.8 cm while from 4 cm onwards the proportion of females was dominant.

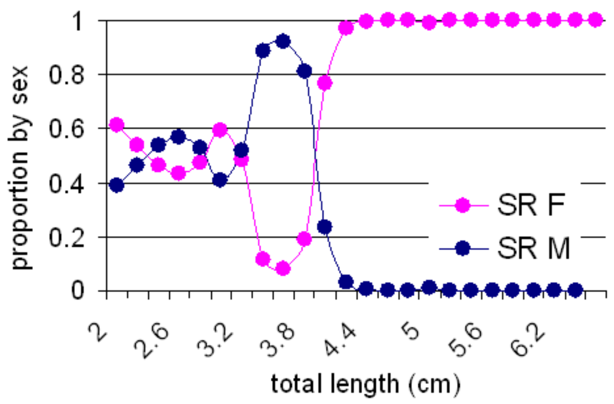


Fig. 5.57.1.3.2 Sex ratio over length.

5.57.2. Fisheries

5.57.2.1. General description of fisheries

The Giant red shrimp is only targeted by trawlers on fishing grounds located offshore deeper than 200 m, mainly southward Salerno Gulf. Catches from trawlers are from a depth range between 400 and 700 m depth and giant red shrimp occurs with *A. antennatus*, *P. longirostris* and *N. norvegicus*, *P. blennoides*, *M. merluccius*, depending on depth and area.

5.57.2.2. Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures, like the number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of the fleet, the Italian fishing licenses have been fixed since the late 1980s. After 2000, in agreement with the European Common Fisheries Policy, a gradual decreasing of the fleet capacity is implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990. Two closed areas were also established in 2004 along the mainland, in front of Sorrento peninsula (Napoli Gulf) and Amantea (Calabrian coasts) although these protected areas mainly cover the distribution of coastal species. Other measures on which the management regulations are based are technical measures (mesh size) and minimum landing sizes (EC reg. 1967/06). In the GSA 10 the fishing ban has not been mandatory and it was adopted on a voluntary basis by the fleet.

5.57.2.3. Catches

5.57.2.3.1. Landings

Available landing data are from DCR regulations. Italian landings data for GSA 10 by major fishing gears are listed in Tab. 5.57.2.3.1.1. Since 2004, landings of the giant red shrimp increased to 505 t in 2005 and decreased to 120 t in 2008. Most part of the landings is from trawlers.

Tab. 5.57.2.3.1.1. Annual landings (t) by gear type, 2004-2008 as reported through the official DCF data call in 2010. The Italian authorities did not submit data for 2009.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
ARS	10	ITA	GNS	DEMSP				4	7	8	9	7	
ARS	10	ITA	OTB	DWSP						57	20	21	
ARS	10	ITA	OTB	MDDWSP				203	498	355	271	92	
Sum								207	505	420	300	120	

5.57.2.3.2. *Fishing effort*

The trends in fishing effort by year and major gear type is listed in Tab. 5.57.2.3.2.1 in terms of kW*days. The fishing effort in kW*days of the trawlers, that is the fishing segment targeting the giant red shrimp, was rising in 2004 and 2005 and decreasing in 2006 and 2007.

Tab. 5.57.2.3.2.1 Trend in fishing effort (kW*days) for GSA10 by major gear types, 2004-2008. No data for 2009 were reported by Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
10	ITA				VL0006				1347			
10	ITA				VL0612		84318	65385	32480	27509	24608	
10	ITA				VL1218		13612	27229	5986	18865	7513	
10	ITA	DRB	MOL		VL1218		10149	14848	23073	34394	21067	
10	ITA	FPO	DEMSP		VL0006				5938			
10	ITA	FPO	DEMSP		VL0612			14239				
10	ITA	GND	SPF		VL0006					1521	1437	
10	ITA	GND	SPF		VL0612			4316	8070		15882	
10	ITA	GND	SPF		VL1218		1895	3429			8303	
10	ITA	GNS	DEMSP		VL0006				221	9122	6623	
10	ITA	GNS	DEMSP		VL0612		45875	229661	74360	139622	124448	
10	ITA	GNS	DEMSP		VL1218						18180	
10	ITA	GTR	DEMSP		VL0006				30332	16894	13248	
10	ITA	GTR	DEMSP		VL0612		86781	82711	191382	140832	172542	
10	ITA	GTR	DEMSP		VL1218		12514	21108	28430	16110	17755	
10	ITA	LHP-LHM	CEP		VL0006				2369	3463	1018	
10	ITA	LHP-LHM	CEP		VL0612		1239	2450	4458	15003		
10	ITA	LHP-LHM	FINF		VL1218		716	1013				
10	ITA	LLD	LPF		VL0006						1968	
10	ITA	LLD	LPF		VL0612						2138	
10	ITA	LLD	LPF		VL1218		4627		10673	10266	14174	
10	ITA	LLS	DEMF		VL0006				11628	3467	2996	
10	ITA	LLS	DEMF		VL0612		104125	101629	61456	56957	26693	
10	ITA	LLS	DEMF		VL1218		13376	27517	61348	52670	32330	
10	ITA	OTB	DEMSP		VL0612		16454					
10	ITA	OTB	DEMSP		VL1218		44743		102448	127832	98014	
10	ITA	OTB	DEMSP		VL1824		90104		224283	204068	242063	
10	ITA	OTB	DWSP		VL1824						2388	
10	ITA	OTB	MDDWSP		VL1218		130612	247796	142430	169560	83026	
10	ITA	OTB	MDDWSP		VL1824		97221	239878	71963	86844	55526	
10	ITA	PS	LPF		VL0612					5291		
10	ITA	PS	LPF		VL1218					4926		
10	ITA	PS	SPF		VL0006				7337			
10	ITA	PS	SPF		VL0612		4653	27986				
10	ITA	PS	SPF		VL1218		49995	54113	68805	73452	20179	
10	ITA	SB-SV	DEMSP		VL0006				0			
10	ITA	SB-SV	DEMSP		VL0612		12786					
10	ITA	SB-SV	DEMSP		VL1218						8756	

5.57.3. *Scientific surveys*

5.57.3.1. Medits

5.57.3.1.1. Methods

According to the MEDITS protocol (Bertrand *et al*., 2002), trawl surveys were carried out yearly (May-July), applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometre, using the swept area method.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls was reported per depth stratum (s. Tab. 5.57.3.1.1.1).

Tab. 5.57.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	9	10	10	10	10	10	10	10	9	9	9	9	9	9	9	9
GSA10_050-100	12	12	12	12	12	12	12	12	10	10	10	10	10	10	10	10
GSA10_100-200	20	20	20	20	20	20	20	20	17	17	17	17	17	17	17	17
GSA10_200-500	26	27	26	26	27	26	26	28	22	22	22	22	22	22	22	22
GSA10_500-800	31	30	31	31	31	30	31	29	26	27	26	26	26	26	26	26

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls considered as valid were used in the analysis, including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

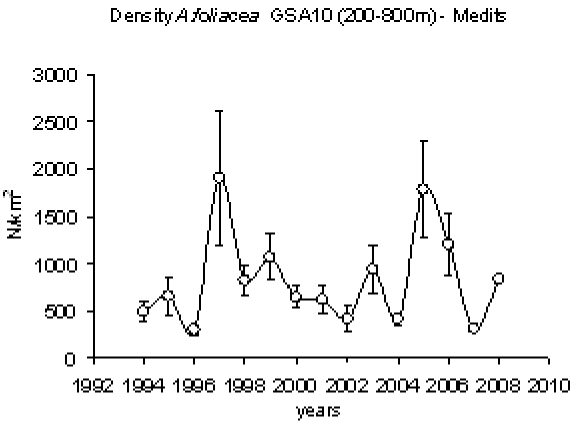
Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.57.3.1.2. Geographical distribution patterns

A comparative analysis of MEDITS and GRUND distribution patterns is presented in the following section 5.57.3.2 under the GRUND survey results.

5.57.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the giant red shrimp in GSA 10 was derived from the international survey Medits. Figure 5.57.3.1.3.1 displays the estimated trend of *A. foliacea* abundance and biomass standardized to the surface unit in GSA 10. Indices from Medits trawl-surveys show a fluctuating pattern with two peaks in 1997 and 2005, but without any trend.



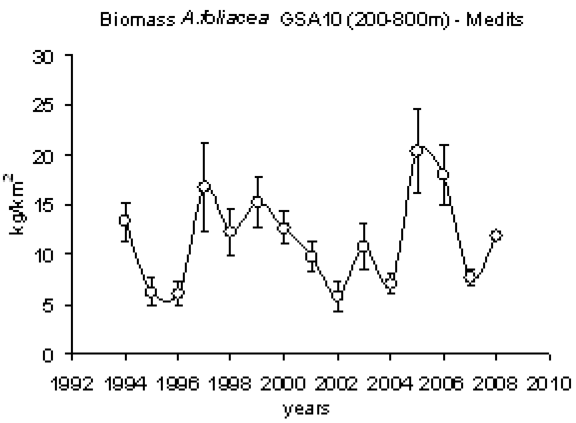


Fig. 5.57.3.1.3.1 Trends in survey abundance and biomass indices standardized to the surface unit and derived from Medits.

Medits indices were re-estimated based on the data obtained from the international data call. Such re-estimated indices from Medits trawl-surveys show a fluctuating pattern with two peaks in 1997 and 2005, but without any trend (Fig. 5.57.3.1.3.2).

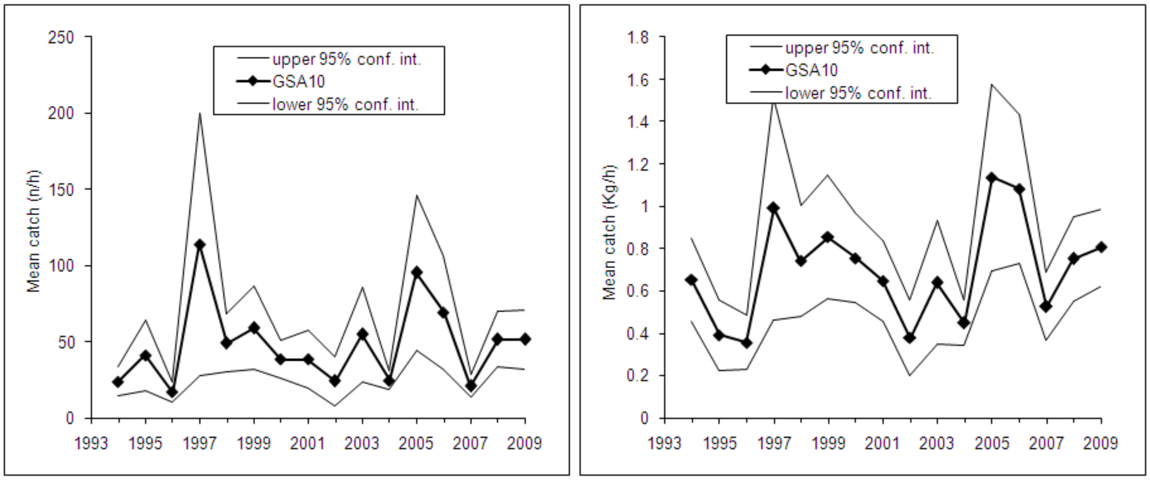


Fig. 5.57.3.1.3.2 Abundance and biomass indices of giant red shrimp in GSA 10.

5.57.3.1.4. Trends in abundance by length or age

The following Fig. 5.57.3.1.4.1 and 2 display the stratified abundance indices of GSA 10 in 1994-2009.

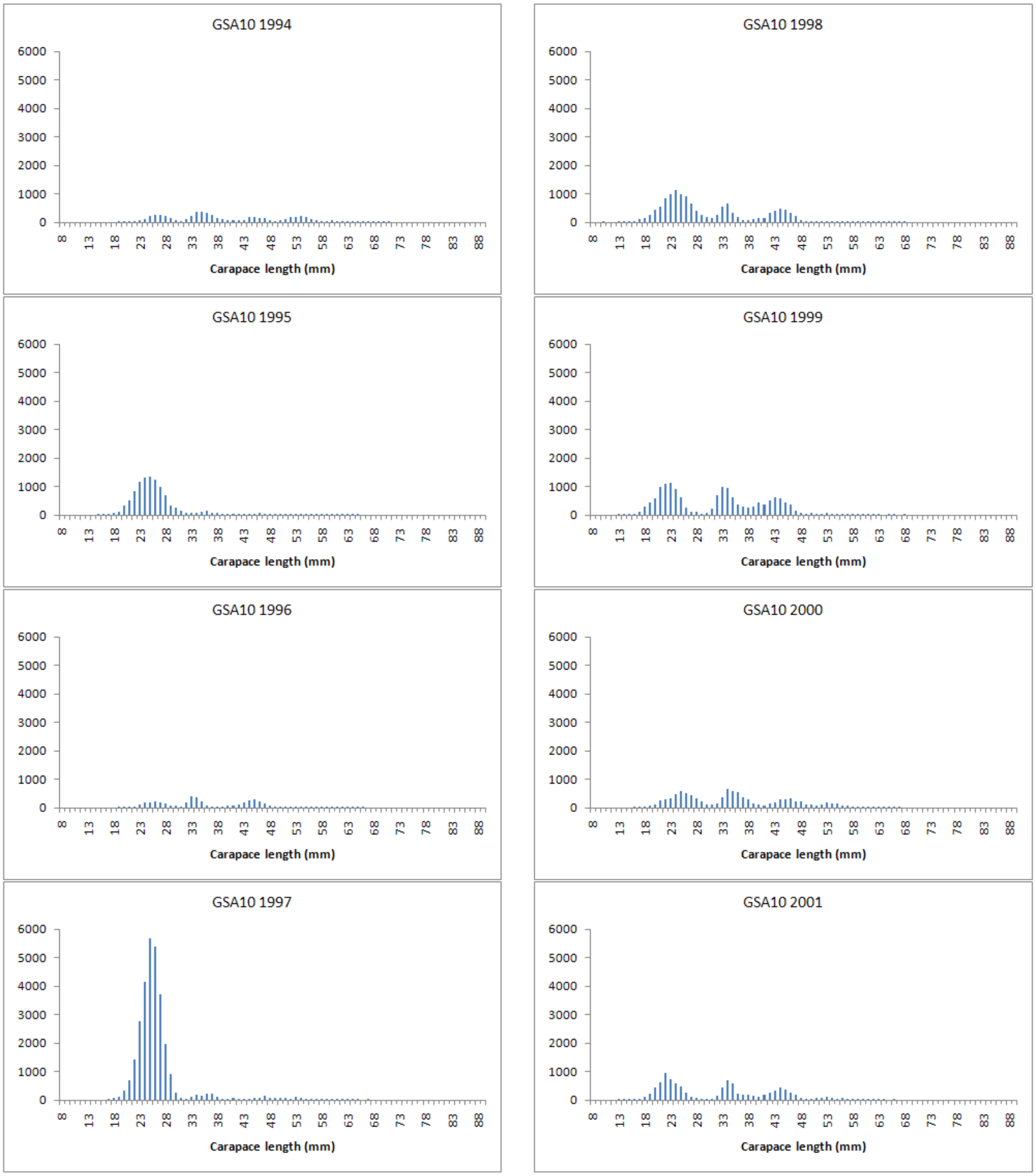


Fig. 5.57.3.1.4.1 Stratified abundance indices by size, 1994-2001.

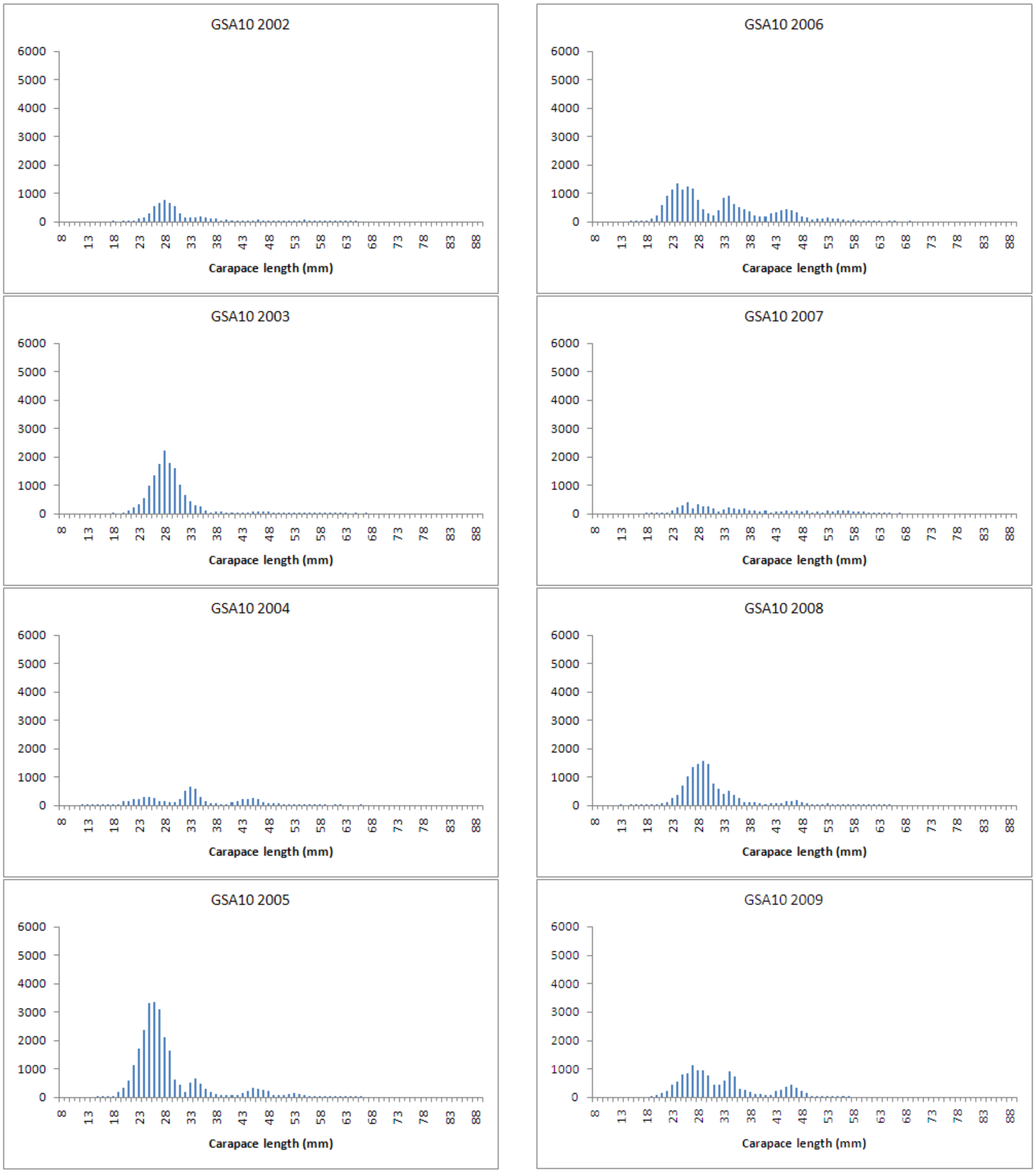


Fig. 5.57.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.57.3.2. GRUND

5.57.3.2.1. Methods

Since 2003 Grund surveys (Relini, 2000) was conducted using the same sampler (vessel and gear) in the whole GSA. Sampling scheme, stratification and protocols were similar as in Medits. All the abundance and biomass data were standardised to the square kilometre, using the swept area method.

5.57.3.2.2. Geographical distribution patterns

The geographical distribution pattern of the giant red shrimp has been studied in the area using trawl-survey data, length frequency distribution analyses via modal component separation techniques and geostatistical methods. The abundance of the whole population, as derived from both Medits and Grund surveys, was higher in the southern part of the GSA, along the Calabrian coast (Fig. 5.57.3.2.2.1) as well as the abundance of recruits (Fig. 5.57.3.2.2.2). The probability of find a nursery area was the highest in the same zone with a high temporal continuity.

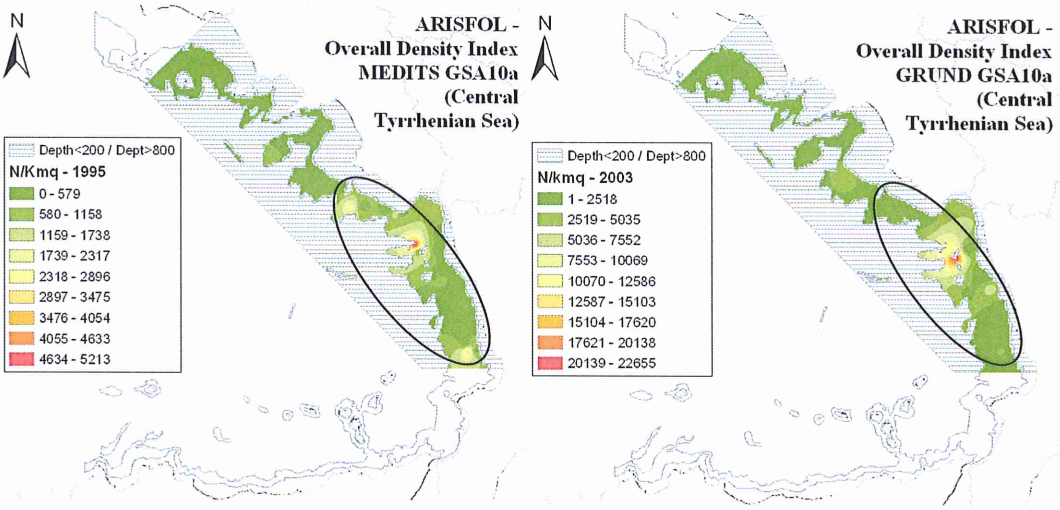


Fig. 5.57.3.2.2.1 Maps of the abundance of the giant red shrimp from Medits and Grund surveys.

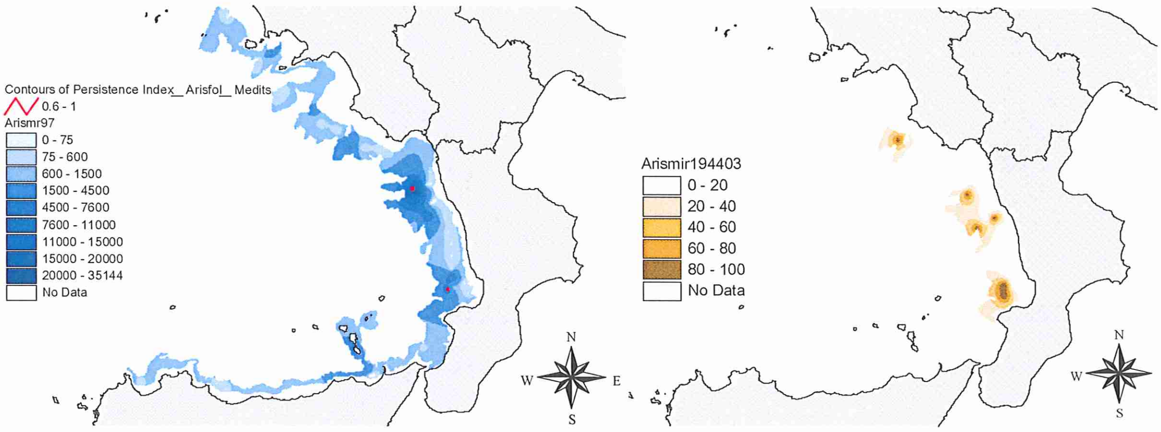


Fig. 5.57.3.2.2.2 Maps of the abundance of the giant red shrimp recruits (left) and of the probability of nursery localization (right) from Medits survey of 1997 and 2003 respectively. The contour of persistence areas is also evidenced in the map of abundance.

5.57.3.2.1. Trends in abundance and biomass

Trends derived from the GRUND surveys are shown in Fig. 5.57.3.2.1.1. Abundance and biomass indices show some peaks and fluctuations, but without any trend, as well as recruitment indices. Higher values are recorded in 2003 and 2005. Although less varying, the pattern is similar to that observed in the Medits series.

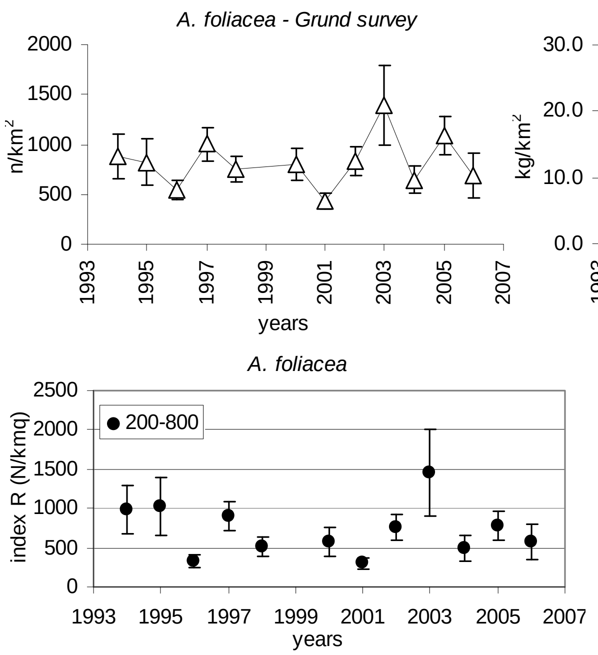


Fig. 5.57.3.2.1.1. Abundance and biomass indices of giant red shrimp in GSA 10 (bars indicate standard deviations) derived from Grund surveys. Recruitment indices (N/km^2) computed in the stratum 200-800 m depth with standard deviation is also reported.

5.57.3.2.2. Trends in abundance by length or age

No trend in the mean length was observed in Medits survey (Fig. 5.57.3.2.2.1), nor at the third quantile lengths, as obtained from the length structures of Grund time series from 1994 to 2006 (Fig. 5.57.3.2.2.2).

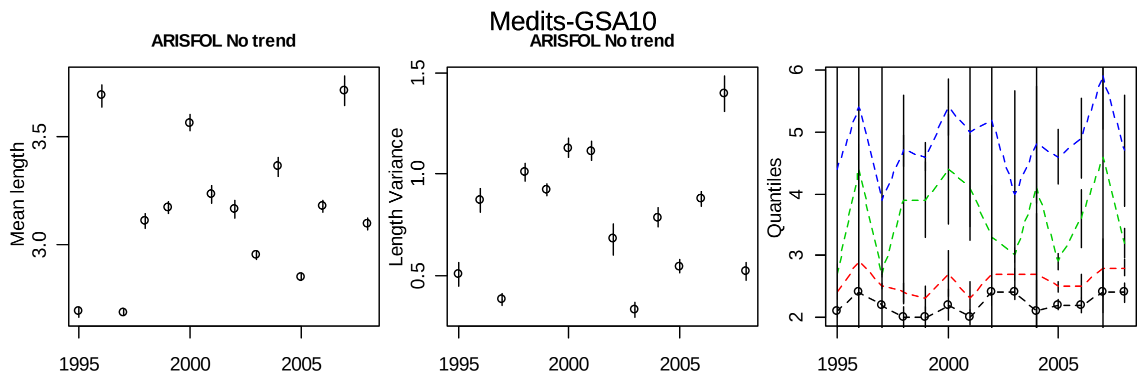


Fig. 5.57.3.2.2.1 Mean length, variance and quantiles derived from the Medits length compositions in 1995-2008.

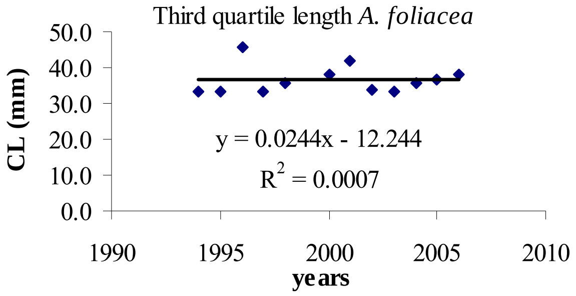


Fig. 5.57.3.2.2.2 III Quantile derived from the GRUND length structures in 1994-2006.

The LFDs are rather varying throughout the Medits surveys, mainly for the recruitment strength that determines a dominance of the juvenile component in the LFDs of 1995, 1997, 2003 and 2005, while in the other years recruits are on average 30-50% of the total distribution (Fig. 5.57.3.2.2.3).

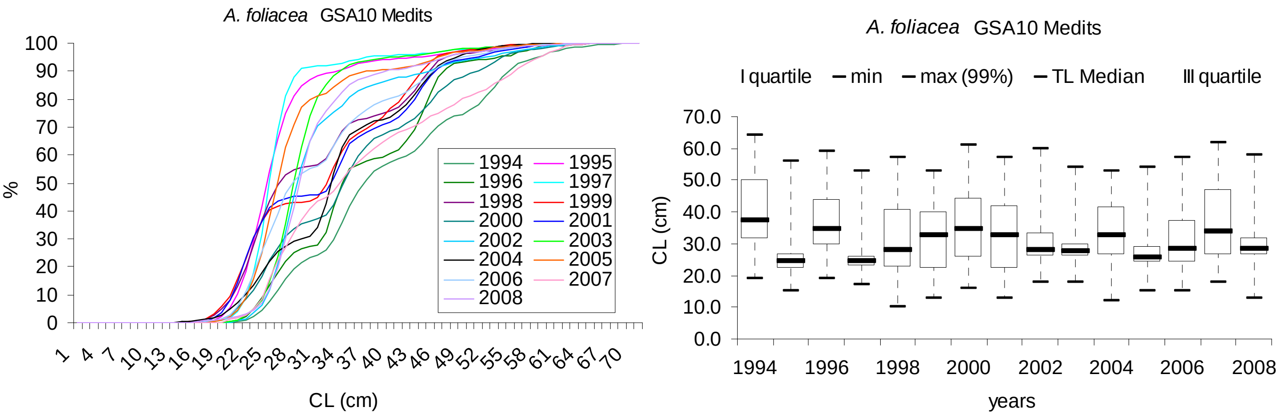


Fig. 5.57.3.2.2.3 Cumulative frequencies of the Medits LFDs (in percentage) and box plots.

5.57.3.2.3. Trends in growth

No analyses were conducted during SGMED-10-02.

5.57.3.2.4. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.57.4. Assessment of historic stock parameters

No analytical assessment of historic stock parameters was conducted.

5.57.5. Long term prediction

5.57.5.1. Justification

No forecast analyses were conducted.

5.57.5.2. Input parameters

No forecast analyses were conducted.

5.57.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a short term prediction of catch and stock biomass for giant red shrimp in GSA 10.

5.57.6. Scientific advice

5.57.6.1. Short term considerations

5.57.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.57.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of recruitment in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.57.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of exploitation given the preliminary state of the data and analyses.

5.58. Stock assessment of giant red shrimp in GSA 11

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.58.1. Stock identification and biological features

5.58.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.58.1.2. Growth

No information was documented during SGMED-10-02.

5.58.1.3. Maturity

No information was documented during SGMED-10-02.

5.58.2. Fisheries

5.58.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.58.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.58.2.3. Catches

5.58.2.3.1. Landings

Tab. 5.58.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. The landings were mainly taken by demersal otter trawls.

Tab. 5.58.2.3.1.1 Annual landings (t) by fishing technique in GSA 11, 2004-2008. The data were reported through the official DCR data call in 2010. No 2009 data are submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
ARS	11	ITA	OTB	DWSP								11	
ARS	11	ITA	OTB	MDDWSP				314	171	129	82	56	
Sum								314	171	129	82	67	

5.58.2.3.2. Discards

According to information available to the SGMED-10-02 no catches of *Aristaeomorpha foliacea* were discarded by the Italian fleet.

5.58.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.58.2.3.3.1.

Tab. 5.58.2.3.3.1 Trends in annual fishing effort by fishing technique deployed in GSA 11, 2004-2008. No 2009 data are submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
11	ITA	FPO	DEMSP		VL0006					8227	1107	
11	ITA	FPO	DEMSP		VL0612				13379	69823	43856	
11	ITA	FPO	DEMSP		VL1218					16165	4731	
11	ITA	FYK	DEMSP		VL0006						0	
11	ITA	GNS	DEMSP		VL0006				0	3950	2439	
11	ITA	GNS	DEMSP		VL0612		22701	54787	5413	44336	35469	
11	ITA	GNS	DEMSP		VL1218		5248	39173	9568	7130	19593	
11	ITA	GTR	DEMSP		VL0006				5465	5988	4328	
11	ITA	GTR	DEMSP		VL0612			38115	82656	176487	116844	
11	ITA	GTR	DEMSP		VL1218		1814	54332	19069	75188	64023	
11	ITA	LHP-LHM	CEP		VL0006					4305	1131	
11	ITA	LHP-LHM	CEP		VL0612		3065		2611	9764	3353	
11	ITA	LHP-LHM	CEP		VL1218					12237	4371	
11	ITA	LHP-LHM	FINF		VL0612						3480	
11	ITA	LLD	LPF		VL1218			6694				
11	ITA	LLD	LPF		VL2440					1975		
11	ITA	LLS	DEMF		VL0006				228	2263	0	
11	ITA	LLS	DEMF		VL0612		50046	61709	4253	76836	29234	
11	ITA	LLS	DEMF		VL1218		3499	34499	20040	43290	25525	
11	ITA	LLS	DEMF		VL2440					13170		
11	ITA	OTB	DEMSP		VL1218		75568	77835	108842		95470	
11	ITA	OTB	DEMSP		VL1824						66067	
11	ITA	OTB	DEMSP		VL2440						22082	
11	ITA	OTB	MDDWSP		VL1218					152444	8561	
11	ITA	OTB	MDDWSP		VL1824		115969	188926	141391	195889	35045	
11	ITA	OTB	MDDWSP		VL2440		213246	234872	190232	187054	126564	
11	ITA	PS	SPF		VL1218		4109					

5.58.3. Scientific surveys

5.58.3.1. Medits

5.58.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 11 the following number of hauls was reported per depth stratum (s. Tab. 5.58.3.1.1.1).

Tab. 5.58.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18
GSA11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20
GSA11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24
GSA11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19
GSA11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.58.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.58.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the giant red shrimp in GSA 11 was derived from the international survey Medits. Figure 5.58.3.1.3.1 displays the estimated trend in giant red shrimp abundance and biomass in GSA 11.

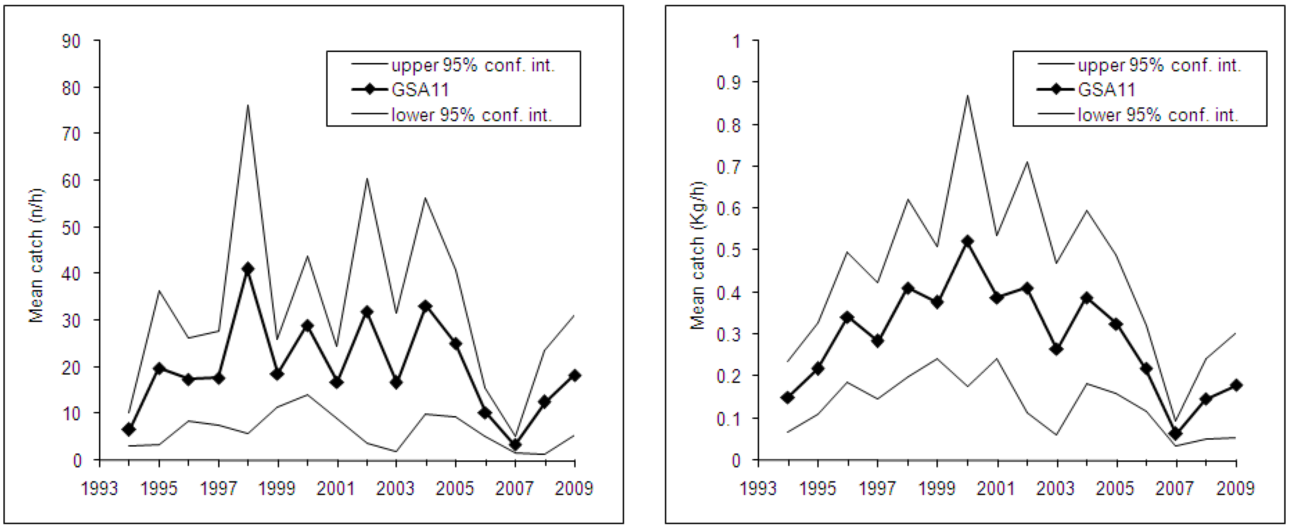


Fig. 5.58.3.1.3.1 Abundance and biomass indices of giant red shrimp in GSA 11.

5.58.3.1.4. Trends in abundance by length or age

The following Fig. 5.58.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2009.

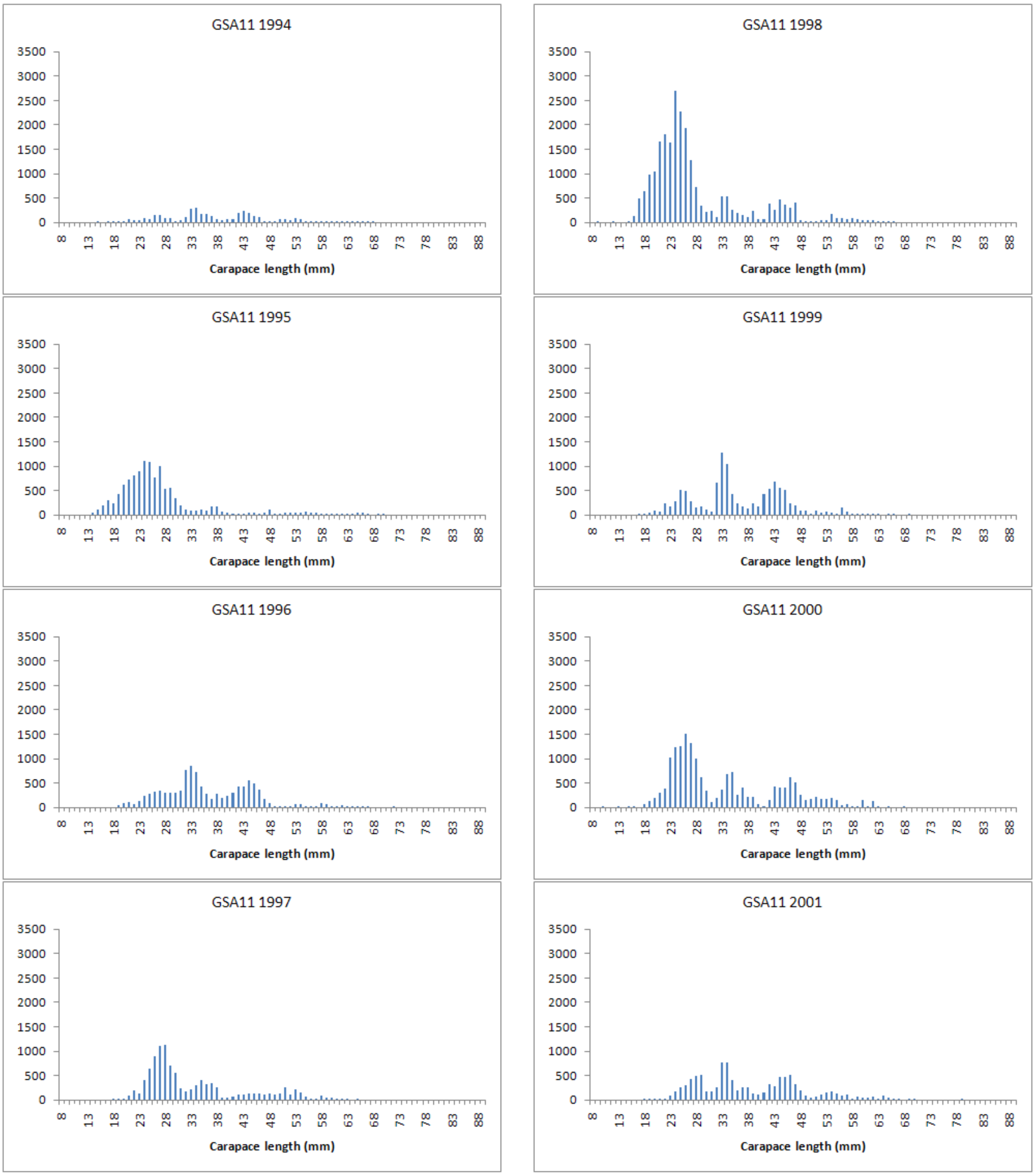


Fig. 5.58.3.1.4.1 Stratified abundance indices by size, 1994-2001.

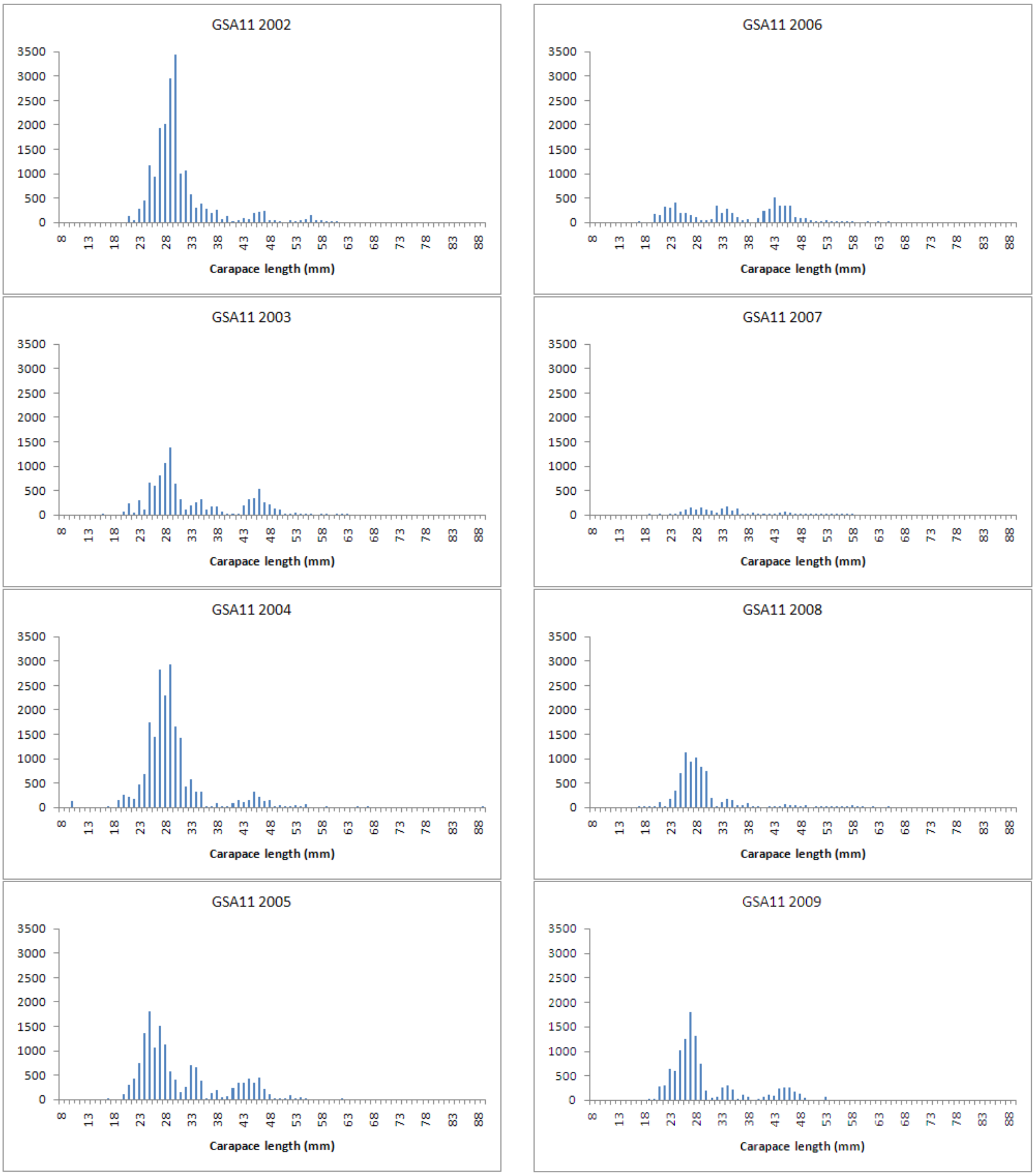


Fig. 5.58.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.58.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.58.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.58.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.58.5. Long term prediction

5.58.5.1. Justification

No forecast analyses were conducted.

5.58.5.2. Input parameters

No forecast analyses were conducted.

5.58.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for giant red shrimp in GSA 11.

5.58.6. Scientific advice

5.58.6.1. Short term considerations

5.58.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.58.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.58.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation given the preliminary state of the data and analyses.

5.59. Stock assessment of giant red shrimp in GSAs 15 and 16

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.59.1. Stock identification and biological features

5.59.1.1. Stock Identification

No information is available to the SGMED-10-02 on stock unity in the area and thus the stock was assumed to be confined within the boundaries of the GSA 15 and 16 also according recommendations made by SGMED-09-01.

5.59.1.2. Growth and natural mortality

Considering the northern sector of the Strait of Sicily (GSA 15 and 16) the observed maximum length was 70 mm. After age slicing with the parameters estimated by CNR-IAMC (2009; Tab. 5.59.1.2.1), the maximum estimated age in years in the exploited part of the stock resulted to be 6 years. The growth parameters estimated in the past for the Strait of Sicily are reported in Tab. 5.59.1.2.1 for comparative purposes.

During SGMED-09-02 new parameters were estimated in order to allow a better performance of the VIT approach. These new parameters, had a higher L_{inf} and lower k than the parameters given by the data call, but were nevertheless characterised by a very similar growth performance (see Φ' column in Tab. 5.59.1.2.1), as obtained by the Powel-Wetherall method (linf) and the ELEFAN "K scan" routine (K). The data used for this application were the length frequency distributions collected in trawl surveys from 1994 to 2008. Parameters were then estimated by the package FISAT II (Gayanilo *et al*., 2005).

Tab. 5.59.1.2.1 Von Bertalanffy growth function, growth performance index and length-weight relationship parameters in the Strait of Sicily (GSA 15 and 16) (L_{inf} as CL in mm).

Reference	Sex	Linf	K	t_0	Φ'	a	b
Ragonese *et al.* (1994)	Females	65.5	0.67	0.28	3.459	/	/
	Males	41.5	0.96	0.28	3.218	/	/
Cau et al. (2002)	Females	65.5	0.67	/	3.459	/	/
AAVV (2008); Red's Project	Females	62.24	0.65	0.05	3.401	0.002	2.507
	Males	40.31	0.79	-0.44	3.108	0.002	2.618
Ragonese *et al.* (2004)	Females	65.8	0.52	-0.23	3.352	0.00176-0.00210	2.51-2.56
	Males	/	/	/	/	0.00116-0.00135	2.65-2.69
CNR-IAMC (2009)	Females	61,66	0,78	-0,22	3.472	0.0016	2.5884
	Males	41.95	0,70	-0,18	3.091	0.0010	2.7456
SGMED 02 09	Females	68.9	0.61	-0.2	3.462	0.0013	2.636

5.59.1.3. Maturity

Although spawning in *A. foliacea* occurs from spring till autumn in the Strait of Sicily, maturity peaks in summer (Ragonese and Bianchini, 1995). According to Ragonese *et al*. (2004) the length at 50% of maturity is 42 mm CL in females and 30-33 mm CL in males. The most recent assessment of maturity ogive was given by CNR-IAMC (2009), with $L_{50\%}$ = 37.17 (es = 0.108) mm CL and slope g = 0.541 (es = 0.028) in females and $L_{50\%}$ = 27.41 (es = 0.0.037) mm CL and slope g = 0.988 (es = 0.031) in males.

5.59.2. Fisheries

5.59.2.1. General description of fisheries

The giant red shrimps is a relevant target species of the Sicilian and Maltese trawlers and is caught on the slope ground during all year round, although landing peaks are observed in summer. *A.foliacea* is fished mainly in the central - eastern side of the Strait of Sicily, whereas in the western side it is substituted by the blue and red shrimp, *Aristeus antennatus.* A rough delimitation of the most important fishing grounds of red shrimps in the Strait of Sicily is reported in Ragonese (1989) (Fig. 5.59.2.1.1). However, due to reduction of catch rates since 2004, some trawlers based in Mazara del Vallo, which is the main fleet in the area, recently moved to the eastern Mediterranean (Aegean and Levant Sea) to fish red shrimps (Garofalo *et al*., 2007).

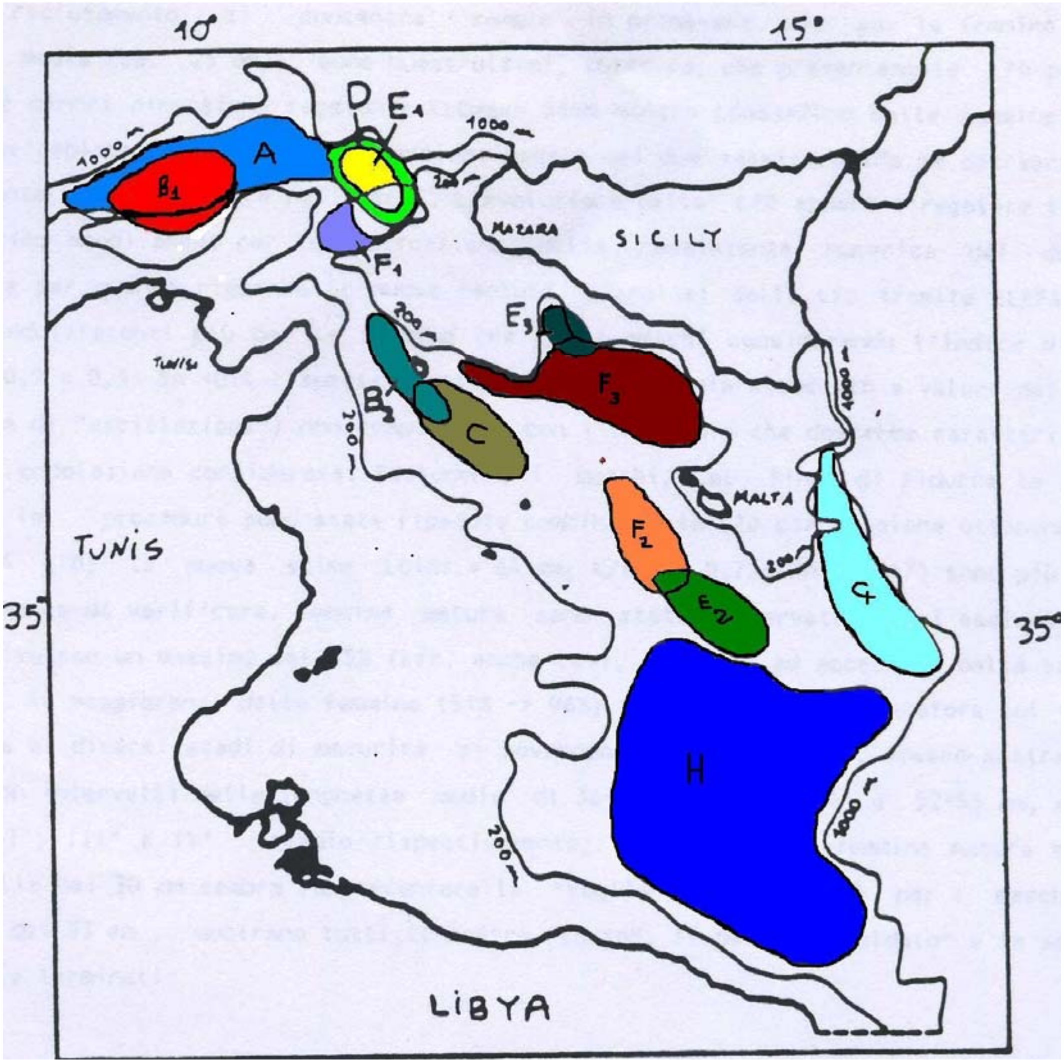


Fig 5.59.2.1.1 Main fishing grounds of red shrimps in the Strait of Sicily according to Ragonese (1989).

In Maltese waters, trawlers targeting the giant red shrimp *A. foliacea* within the 25 nm fisheries management zone trawl either to the north / north-west of the Island of Gozo, or to the west / south-west of Malta, at depths of about 600 m. Detailed maps of the trawling grounds for Maltese Fisheries Management Zone (FMZ), including a wide part of GSA 15 will soon be available in Camilleri *et al*. (in press).

In terms of fishing gear, the Italian and Maltese trawlers operating in the Strait of Sicily use the same typology of trawl net called "Italian trawl net", which is a type of otter trawl. Although some differences in material between the net used in shallow waters ("banco" net, mainly targeting shelf fish and cephalopods) and that employed in deeper ones ("fondale" net, mainly targeting deep water crustaceans) exist, the Italian trawl net is characterized by a low vertical opening (up to 1.5 m) with dimensions changing with engine power (Fiorentino *et al*., 2003). Using this gear, giant red shrimps are frequently caught together with Norway lobster (*Nephrops norvegicus*), large sized deep water pink shrimp (*Parapenaeus longirostris*), the more rare blue and red shrimp (*Aristeus antennatus*) as well as large hake (*Merluccius merluccius*).

5.59.2.2. Management regulations applicable in 2009 and 2010

At present there are no formal management objectives for giant red shrimp fisheries in the Strait of Sicily. As in other areas of the Mediterranean, the stock management is based on control of fishing capacity (licenses), fishing effort (fishing activity) and technical measures (mesh size and area/season closures). In addition, a compulsive fishing ban for 30 days was adopted by Sicilian Government (August - September). No minimum landing sizes have been established for this species (EC 1967/06).

In Maltese waters there are no closed seasons, however in order to limit the over-capacity of fishing fleet, Maltese fishing licenses have been fixed at a total of 16 trawlers since 2000. Eight new licences were however issued in 2008, a move made possible under EU law by the reduction of the capacities of other Maltese fishing fleets. Moreover, the Maltese Islands are surrounded by a 25 nautical miles (nm) fisheries management zone, where fishing effort and capacity are being managed by limiting vessel sizes, as well as total vessel engine powers (EC 813/04; EC 1967/06). Trawling is allowed within this designated conservation area, however only by vessels not exceeding an overall length of 24 m. Such vessels fishing in the management zone hold a special fishing permit in accordance with Article 7 of Regulation (EC) No 1627/94, and are included in a list containing their external marking and vessel's Community fleet register number (CFR) to be provided to the Commission annually by the Member State. Moreover, the overall capacity of the trawlers allowed to fish in the 25 nm zone can not exceed 4,800 kW, and the total fishing effort of all vessels is not allowed to exceed an overall engine power and tonnage of 83,000 kW and 4,035 GT respectively. The fishing capacity of any single vessel with a license to operate at less than 200 m depth can not exceed 185 kW. In addition, the use of all trawl nets within 1.5 nm of the coast is prohibited according to EC regulation 1967/2006, although a transitional derogation is at present in place until 2010.

In terms of technical measures, the EC regulation 1967/2006 fixed a minimum mesh size of 40 mm for bottom trawling of EU fishing vessels (Italian and Maltese trawlers). Mesh size had to be modified to square 40 mm or diamond 50 mm in July 2008, however derogations are possible up to 2010.

In addition to these management measures, the protection of spawning grounds has been suggested to be one of the most effective management approaches to enhance recruitment whilst maintaining the reproductive potential of the populations. Similarly, reducing fishing effort on juveniles is vital if stocks are to be harvested at maximum sustainable yield, in particular when juveniles are vulnerable to unselective fishing gears. The location of nursery and spawning areas of *A. foliacea* was recently identified using MEDITS trawl survey data from GSA 15 (2003-2007). The distribution of mature and immature individuals of *N. norvegicus* and *A. foliacea* was however found to be patchy, with sites distributed throughout the waters lying to the west / northwest of the Maltese Islands (Fig 5.59.2.2.1 and Fig 5.59.2.2.2). This makes difficult the designation of a single protected area for protecting the vulnerable life cycle stages of this species.

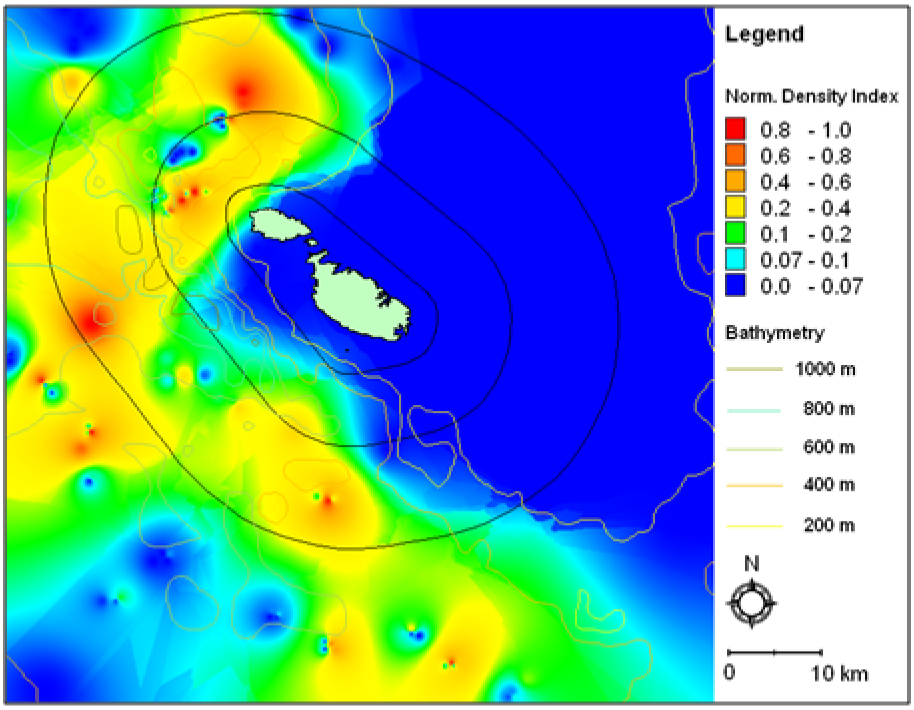


Fig. 5.59.2.2.1: Map of GSA 15, showing distribution of normalised density indices for immature *A. foliacea.*

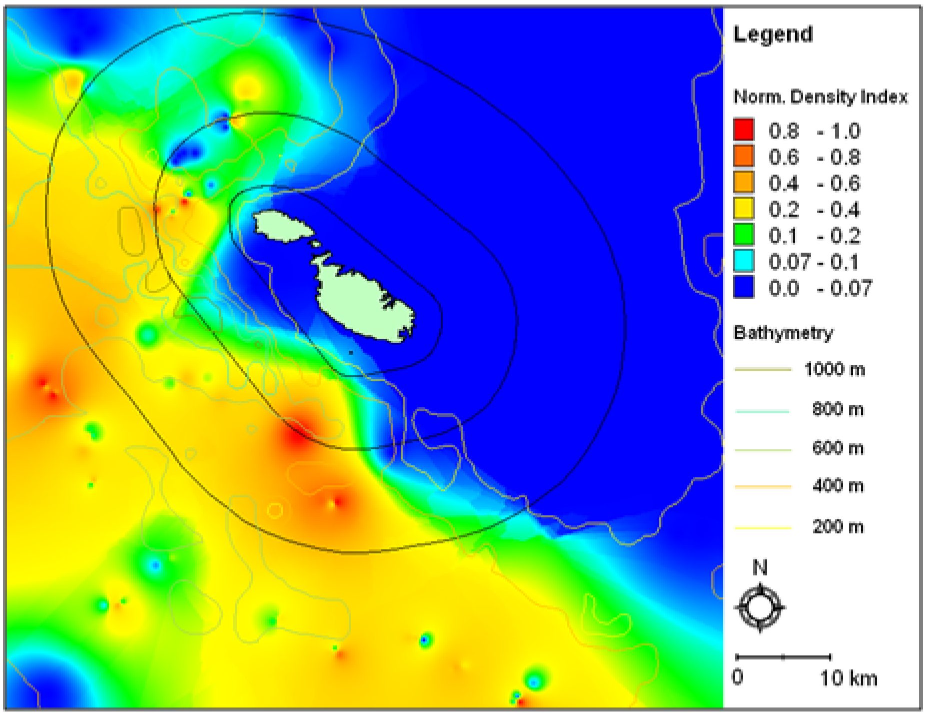


Fig. 5.59.2.2.2: Map of GSA 15, showing distribution of normalised density indices for mature *A. foliacea.*

5.59.2.3. Catches

5.59.2.3.1. Landings

Yield of the Italian trawlers in 2006 was about 1,424 t decreasing to 1,260 t in 2008. The Maltese trawlers landed between 18 t and 42 t during 2004-2009.

Tab. 5.59.2.3.1.1 Landings (t) by year and major gear types, 2004-2009 as reported through DCF. Italian authorities did not submit 2009 data.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
ARS	15	MAL	OTB	MDDWSP					18				
ARS	15	MAL	OTB	MDDWSP	40SXX					26	34	27	42
ARS	16	ITA	OTB	DWSP					23			967	
ARS	16	ITA	OTB	MDDWSP				786	1247	1424	1541	293	
Sum								786	1288	1450	1575	1287	42

The most recent Italian and Maltese data were collected within the framework of the DCR. Available information is considered feasible by the experts attending the working group.

In GSA 15 about 704 tonnes of fish were landed in 2007. The most landed species in terms of weight were *Thunnus thynnus* (34%), *Coryphaena hippurus* (25%), *Xiphias gladius* (19%). These species together constitute about 78 % of the total landed catch in 2007. *A. foliacea* was the most landed crustacean by total weight, making up 1.3% of catches. The following table summarises the percentage distribution of landings estimated through sales vouchers.

Tab. 5.59.2.3.1.2 Landed catch for GSA 15 in 2007 estimated through sales vouchers (from Malta Technical Report 2007).

Species	**% importance of total catch**
Thunnus thynnus	34.2
Coryphaena hippuris	25.2
Xiphias gladius	19.3
Squalus blainvillei	1.8
Boops boops	1.5
Scorpaena scrofa	1.4
Aristaeomorpha foliacea	1.3
Epinephelus spp.	1.3
Others	14.0
Grand Total	**100%**

Regarding length compositions of landings, information is only available for Sicilian vessels (Fig. 5.59.2.3.1.1). Data were considered representative since the 3rd quarter of 2005, when a sampling scheme allowing a realistic raising of the sampled catches to the total ones was adopted (SIBM, 2005).

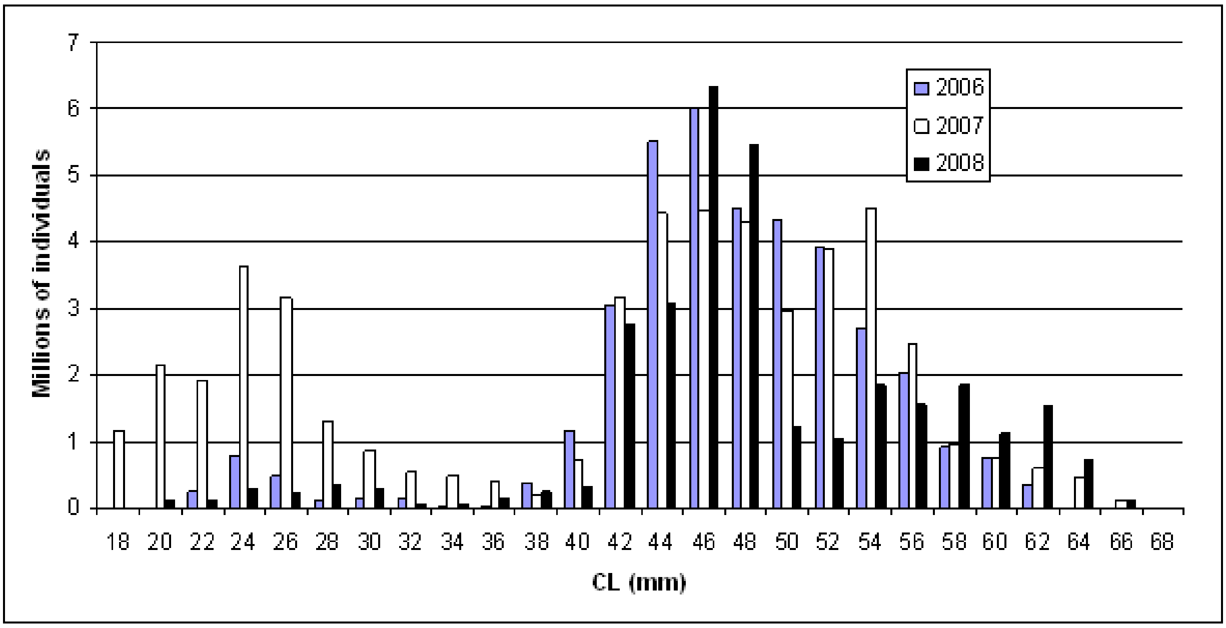


Fig. 5.59.2.3.1.1 Yearly length structure of giant red shrimp landings (females) in absolute numbers of Sicilian trawlers (GSA 16).

5.59.2.3.2. Discards

According to information available to the SGMED-10-02 no catches of red shrimp were discarded by Italian trawlers. An assessment of the discards made by the Maltese fishing industry was carried out in 2005. Results showed that there is no discard practice amongst boats smaller than 10 m and that for larger boats the discard rate is negligible (average 4.7%). More detailed information on volume and species composition of the discards of vessels larger than 10 m by gear type and fleet segment is at present being compiled under the new Data Collection Framework. The bottom otter trawl fleet is being monitored monthly since January 2009, however preliminary analyses are still not available.

5.59.2.3.3. Fishing effort

The trends in fishing effort by year and major gear type is listed in Tab. 5.59.2.3.3.1 and shown in Fig. 5.59.2.3.3.1 in terms of GT*days for the otter trawls.

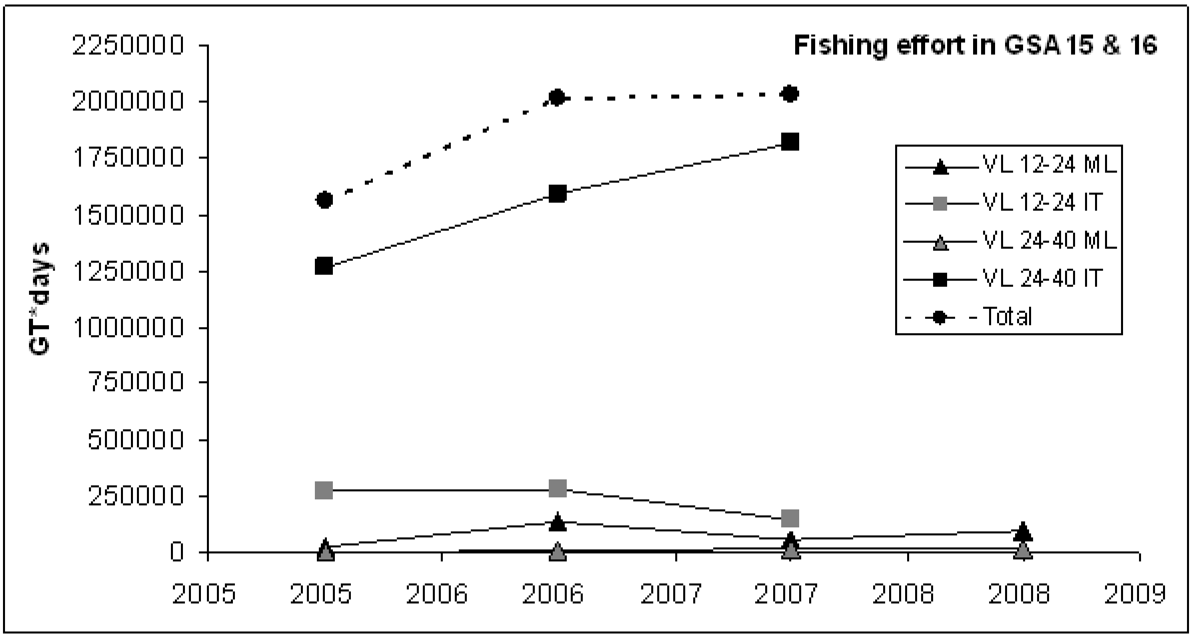


Fig. 5.59.2.3.3.1 Fishing effort in terms of GT*days of trawlers targeted to demersal species in GSAs 15 and 16 as reported in 2009 through the DCR.

Tab. 5.59.2.3.3.1 Annual effort of trawlers as Kw*days by country and vessel length in GSAs 15 and 16, 2004-2009 as reported through the DCF in 2010. No 2009 data were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
15	MAL	FPO	DEMF		VL0006							4594
15	MAL	FPO	DEMF		VL0012						49249	
15	MAL	FPO	DEMF		VL0612							27061
15	MAL	FPO	DEMF		VL1224						1522	
15	MAL	GNS	DEMF		VL0012			1830			4379	
15	MAL	GNS	DEMF		VL1224			291				
15	MAL	GNS	DEMF	16D20	VL0006							346
15	MAL	GNS	DEMF	16D20	VL0612							1058
15	MAL	GNS	SLPF	16D20	VL0006							301
15	MAL	GNS	SLPF	16D20	VL0612							909
15	MAL	GTR	DEMF		VL0012			8364	6899	19700	14197	
15	MAL	GTR	DEMF		VL1224			5316	1492	1024	164	
15	MAL	GTR	DEMF		VL2440			209				
15	MAL	GTR	DEMF	16D20	VL0006							1222
15	MAL	GTR	DEMF	16D20	VL0612							2952
15	MAL	LA	SLPF		VL0012				54906	35688	46987	
15	MAL	LA	SLPF		VL0612							65405
15	MAL	LA	SLPF		VL1218							130081
15	MAL	LA	SLPF		VL1224				148455	160497	128657	
15	MAL	LA	SLPF		VL1824							34808
15	MAL	LA	SLPF		VL2440					12272		
15	MAL	LHM	CEP		VL0006							1729
15	MAL	LHM	CEP		VL0012						9497	
15	MAL	LHM	CEP		VL0612							2500
15	MAL	LHM	CEP		VL1224						298	
15	MAL	LHM	FINF		VL0012			5406			67	
15	MAL	LHM	FINF		VL1224			1352				
15	MAL	LHM	LPF		VL0012						9102	
15	MAL	LHM	LPF		VL1224						403	
15	MAL	LLD	LPF		VL0006							1971
15	MAL	LLD	LPF		VL0012			92350		107473	195062	
15	MAL	LLD	LPF		VL0612							202557
15	MAL	LLD	LPF		VL1218							199948
15	MAL	LLD	LPF		VL1224			420481		330062	299467	
15	MAL	LLD	LPF		VL1824							185676
15	MAL	LLD	LPF		VL2440			41731		12365	7811	41358
15	MAL	LLS	DEMF		VL0006							5242
15	MAL	LLS	DEMF		VL0012			47773	82092	81472	141656	
15	MAL	LLS	DEMF		VL0612							101973
15	MAL	LLS	DEMF		VL1218							40027
15	MAL	LLS	DEMF		VL1224			79870	73824	79442	68490	
15	MAL	LLS	DEMF		VL1824							8556
15	MAL	LLS	DEMF		VL2440			13204	3775			634
15	MAL	LTL	LPF		VL0006							1179
15	MAL	LTL	LPF		VL0012			13009	8073			
15	MAL	LTL	LPF		VL0612							3270
15	MAL	LTL	LPF		VL1224			13100	2137			
15	MAL	LTL	LPF		VL2440			209				
15	MAL	OTB	MDDWSP		VL1224			128047	133167	201767	352184	
15	MAL	OTB	MDDWSP		VL2440			1790	10742	39090	30358	
15	MAL	OTB	MDDWSP	40SXX	VL1824							340113
15	MAL	OTB	MDDWSP	40SXX	VL2440							59792
15	MAL	PS	LPF		VL2440						13920	
15	MAL	PS	LPF	14D16	VL2440							15442
15	MAL	PS	SPF		VL0012						6490	
15	MAL	PS	SPF		VL1224						35413	
15	MAL	PS	SPF	14D16	VL0612							373
15	MAL	PS	SPF	14D16	VL1218							14890
15	MAL	PS	SPF	14D16	VL1824							14920
15	MAL	SB-SV	DEMF		VL0006							286
15	MAL	SB-SV	DEMF		VL0012					2343	1334	
15	MAL	SB-SV	DEMF		VL0612							679
15	MAL	SB-SV	DEMF		VL1224					164		
15	MAL	TBB	DEMF		VL0012						493	
15	MAL	TBB	DEMF		VL0612							82
15	MAL	TBB	DEMF		VL1224						1292	
16	ITA				VL0612			3886			417	
16	ITA	GTR	DEMSP		VL0006				8548	9979	12285	
16	ITA	GTR	DEMSP		VL0612		164944	178522	76073	103953	103352	
16	ITA	GTR	DEMSP		VL1218		25926	7720	23894	18868	8189	
16	ITA	GTR	DEMSP		VL1824			1420				
16	ITA	LHP-LHM	CEP		VL0006				525	1162		
16	ITA	LHP-LHM	FINF		VL0612		16931	16553	14973	15019	21934	
16	ITA	LHP-LHM	FINF		VL1218		641					
16	ITA	LLD	LPF		VL1218		12401	3900	2924	3435	16936	
16	ITA	LLD	LPF		VL1824		36304	5756	1029	78320	12919	
16	ITA	LLS	DEMF		VL0006				1022	3942	1394	
16	ITA	LLS	DEMF		VL0612		26733	58661	12698	57631	9512	
16	ITA	LLS	DEMF		VL1218		21984	1640	3115	62773	18439	
16	ITA	LLS	DEMF		VL1824		1870					
16	ITA	OTB	DEMSP		VL1218		210042	238629	272220		263191	
16	ITA	OTB	DEMSP		VL1824		54367	13425			397440	
16	ITA	OTB	DEMSP		VL2440						693213	
16	ITA	OTB	DWSP		VL1824						15246	
16	ITA	OTB	DWSP		VL2440						41113	
16	ITA	OTB	MDDWSP		VL1218					285378	4336	
16	ITA	OTB	MDDWSP		VL1824		377936	418914	434834	549867	93949	
16	ITA	OTB	MDDWSP		VL2440		1E+06	1E+06	442196	1E+06	225904	
16	ITA	OTM	MDPSP		VL1824				21611	26555	41792	
16	ITA	OTM	MDPSP		VL2440		5306		9096			
16	ITA	PS	LPF		VL1824						9763	
16	ITA	PS	SPF		VL0006						397	
16	ITA	PS	SPF		VL0612			8471		670	3127	
16	ITA	PS	SPF		VL1218		1772	1997	1355		2354	
16	ITA	PS	SPF		VL1824		17339	12429	7349	39307	11625	
16	ITA	PTM	SPF		VL1824			19612	72116	107330	38857	

5.59.3. Scientific surveys

5.59.3.1. Medits

5.59.3.1.1. Methods

In GSA 15 and 16 the following number of hauls was reported per depth stratum (s. Tab. 5.59.3.1.1.1).

Tab. 5.59.3.1.1.1 Number of hauls per year and depth stratum in GSAs 15 and 16, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA15_010-050									1	2	4	1	1			
GSA15_050-100									6	9	7	5	5	12	6	6
GSA15_100-200									12	23	23	13	13	12	12	15
GSA15_200-500									9	18	16	9	9	4	9	10
GSA15_500-800									18	28	27	17	16	17	17	15
GSA16_010-050	4	4	4	4	4	4	4	4	7	7	7	10	10	11	11	11
GSA16_050-100	9	8	8	8	8	8	7	8	11	12	12	20	22	23	23	23
GSA16_100-200	4	4	4	4	5	5	6	5	11	10	11	20	19	21	21	21
GSA16_200-500	10	11	11	12	11	11	11	11	19	18	26	37	31	27	27	27
GSA16_500-800	10	14	14	13	14	14	14	14	20	20	21	33	33	38	38	38

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.59.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02. However some information on aggregates of female spawners have been reported by Ragonese and Bianchini (1995).These are shown in Fig. 5.59.3.1.2.1 below.

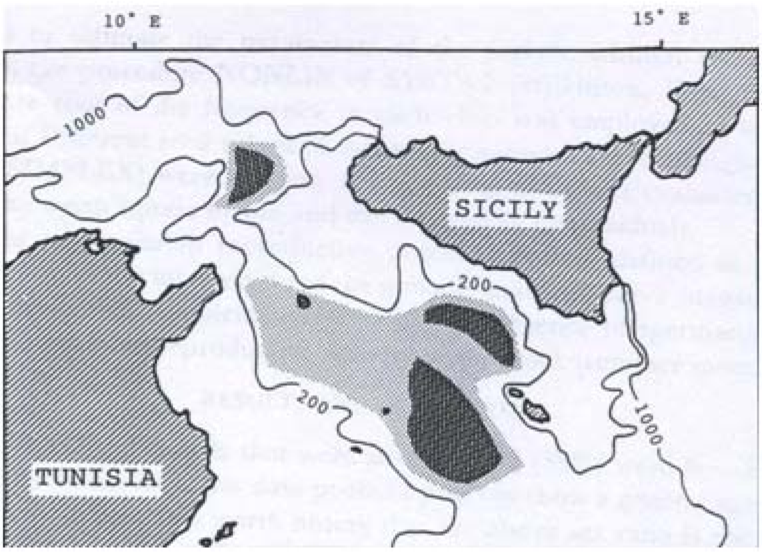


Fig. 5.59.3.1.2.1 Spawning areas of female according to Ragonese and Bianchini (1995).

5.59.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the giant red shrimp in GSAs 15 and 16 was derived from the international surveys MEDITS. Fig. 5.59.3.1.3.1 and Fig. 5.59.3.1.3.2 indicate the stock to vary without an evident trend in the last year (2002-2008). However, the abundance and biomass of giant red shrimp consistently increased in both GSAs since 2007.

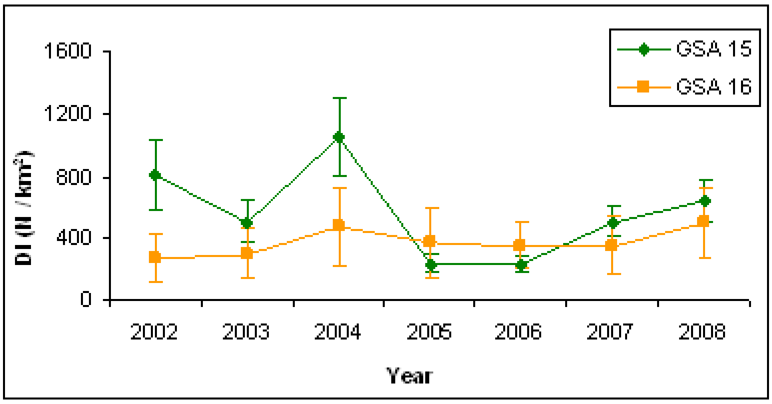


Fig. 5.59.3.1.3.1 DI in N/km^2 (MEDITS survey data) in GSAs 15 and 16 for female *A. foliacea*. Only slope grounds were considered (201-800 m).

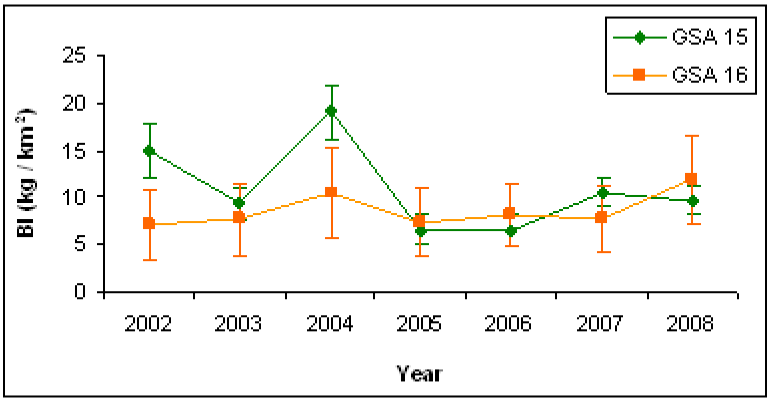
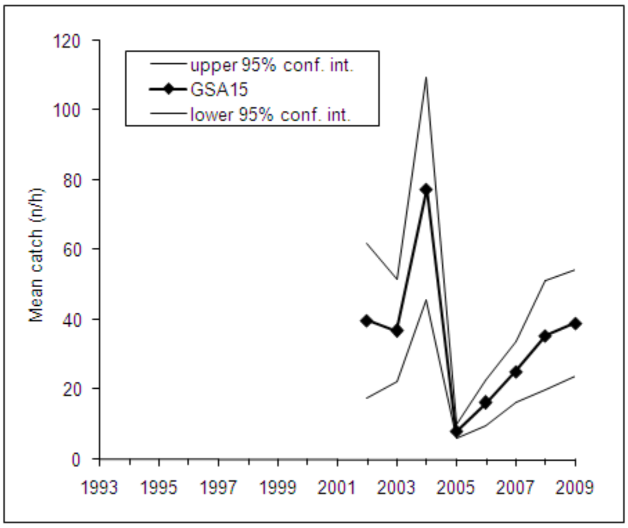


Fig 5.59.3.1.3.2. BI in kg/km^2 (MEDITS survey data) in GSAs 15 and 16 for female *A. foliacea*. Only slope ground was considered (201-800 m).

The trend in abundance and biomass as re-estimated by SGMED-10-02 are shown in Figures 5.59.3.1.3.3 and 5.59.3.1.3.4 for GSAs 15 and 16.



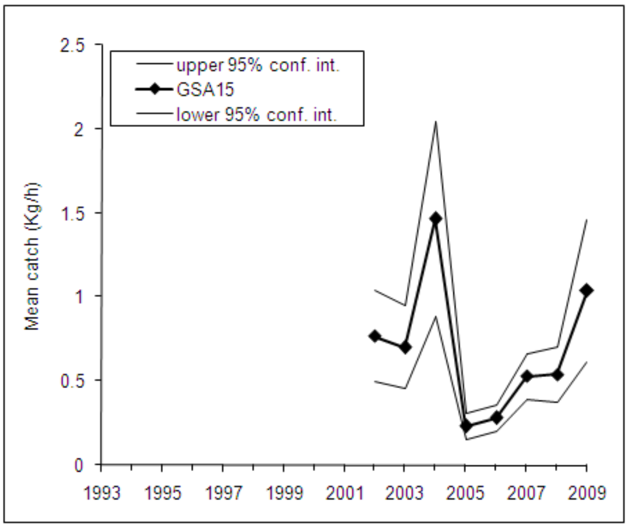


Fig. 5.59.3.1.3.4 Abundance and biomass indices of giant red shrimp in GSA 15.

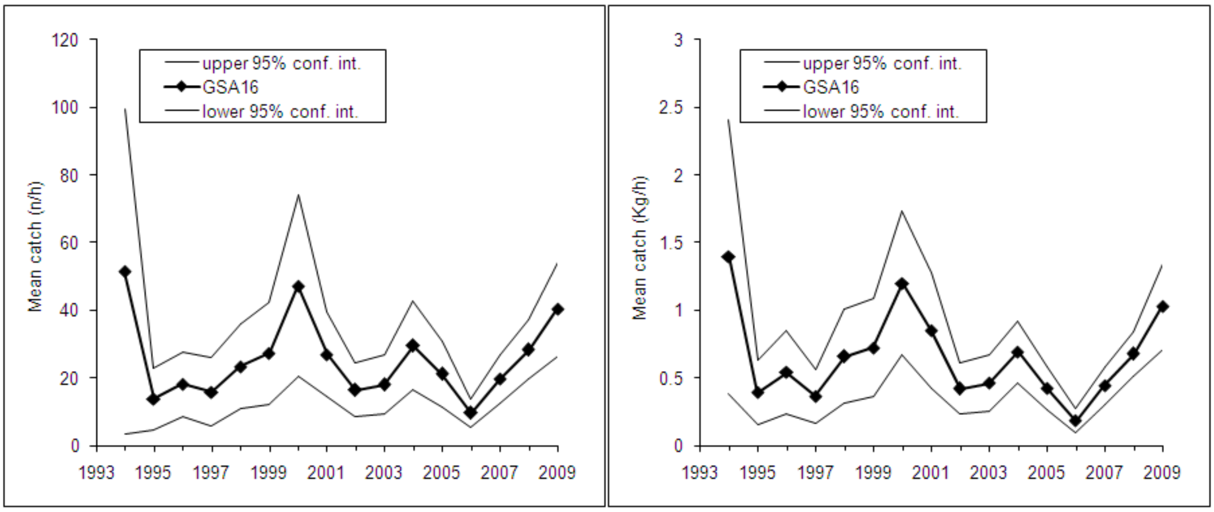


Fig. 5.59.3.1.3.5 Abundance and biomass indices of giant red shrimp in GSA 16.

5.59.3.1.4. Trends in abundance by length or age

Fig. 5.59.3.1.4.1 displays the stratified abundance indices (strata d and e) of giant red shrimp in GSAs 15 and 16 in 2002-2009.

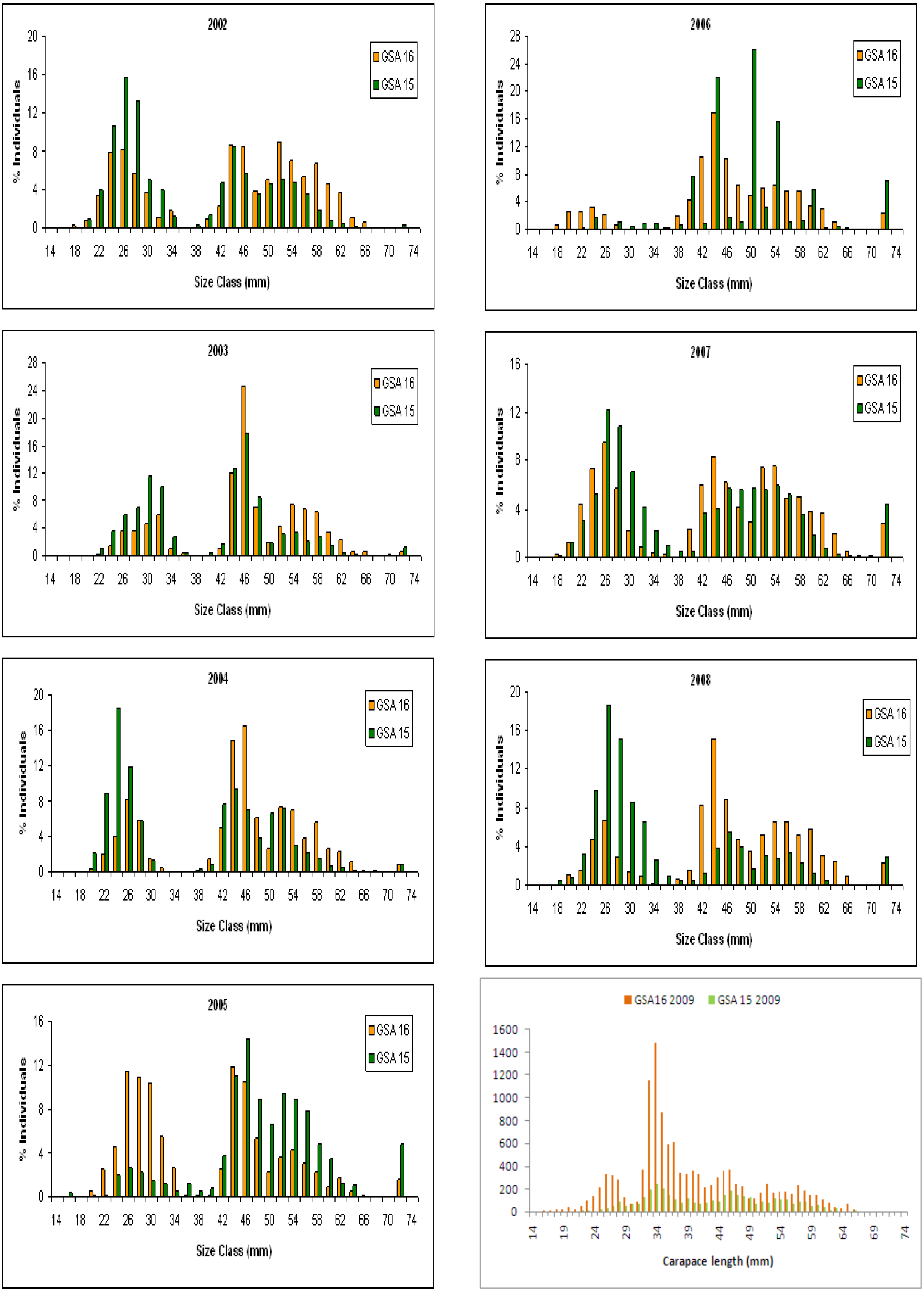


Fig. 5.59.3.1.4.1 Stratified abundance indices by size class in GSAs 15 and 16, 2002-2009.

Figure 5.59.3.1.4.2 displays the stratified abundance indices of giant red shrimp in GSA 16 in 1994-2001.

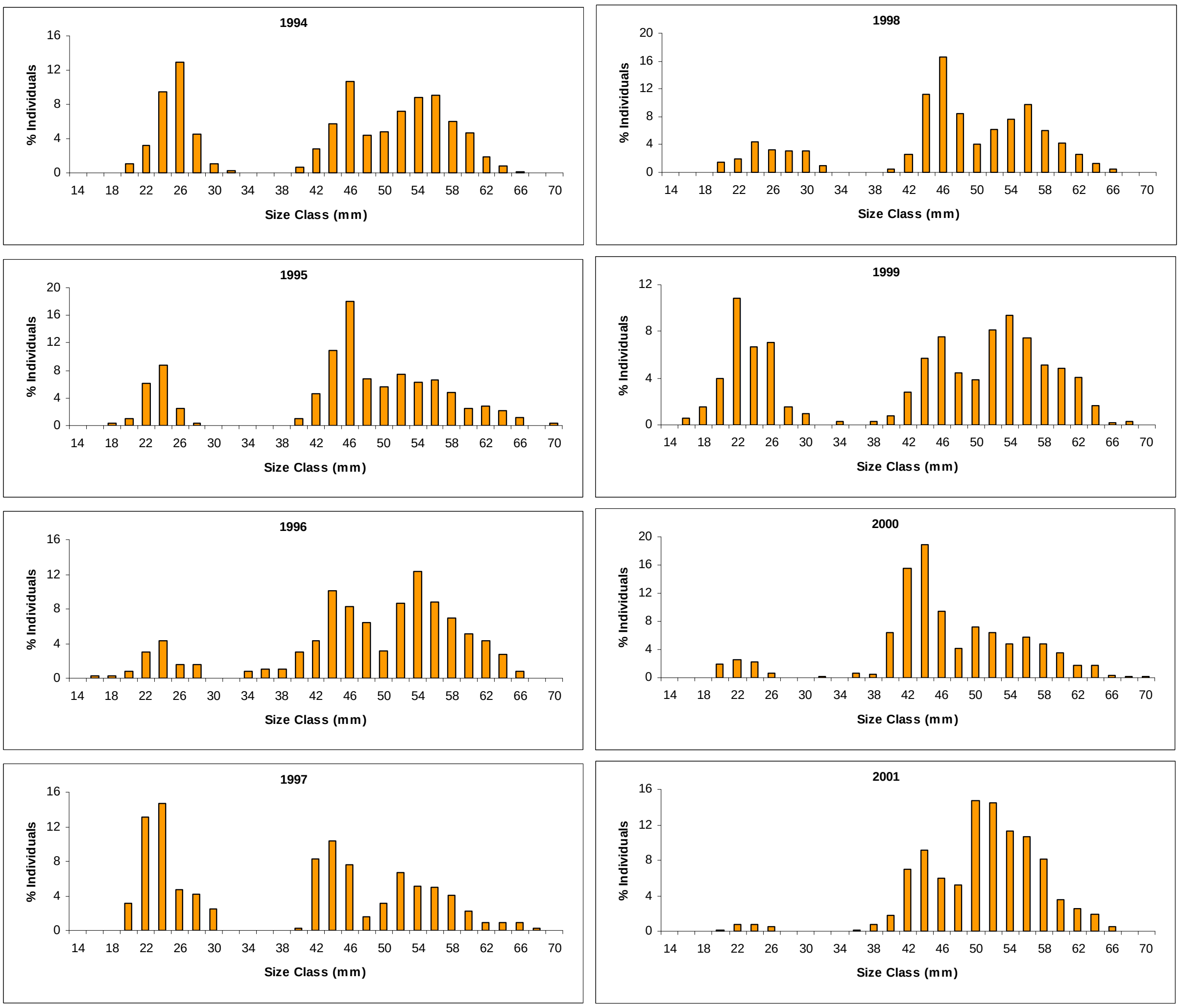


Fig. 5.59.3.1.4.2 Stratified abundance indices by size class in GSA 16, 1994-2001.

5.59.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.59.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.59.4. Assessment of historic stock parameters

5.59.4.1. Method 1: SURBA

5.59.4.1.1. Justification

The availability of length frequency distribution (LFD) time series (2002-2008 for GSA 15 and 1994-2008 for GSA 16) from trawl survey data allowed the reconstruction of the evolution of main stock parameters (recruitment and spawning stock biomass indices, as well as fishing mortality rates) of giant red shrimps in the GSA 15 and 16 by using the SURBA software package. Since females reach the largest size and they are more sensitive to fishery pressure, analyses were carried out only on the female fraction, which represented about 70% of the commercial catches (Gancitano *et al*., 2008).

Firstly the LFD by sex from the MEDITS trawl surveys was corrected by including the data for the individuals with unidentified sex. This was based on the sex ratio per size class. The corrected LFDs by sex for each GSA were then converted in numbers by age group using the subroutine “age slicing” as implemented in the software package LFDA (Kirkwood *et al*., 2001). Secondly we estimated the mean weight and maturity at age using VBGF and natural mortality at age (PROBIOM excel sheet as implemented by Abella in SGMED-09-01) for the SURBA software to run the analysis. Then the numbers at age were used to estimate time series of fishing mortality rates, as well as recruitment and SSB indices. This was done due to the difficulties in obtaining feasible information from commercial fisheries data, especially from GSA 15 where length frequencies distributions from landings do not exist. For GSA 16 data from commercial fisheries were only available since 2002, when the DCR regulation (EC 1639/01; EC 1581/04) was implemented, although data were considered reliable since 2005.

5.59.4.1.2. Input parameters

The input parameters are reported in Tab. 5.59.4.1.2.1.

Tab. 5.59.4.1.2.1 Biological parameters used for SURBA analyses for giant red shrimp (females) in the Strait of Sicily (GSAs 15 and 16).

Growth			maturity		weight	
L_{inf}	K	t_0	Lm	g	a	b
68.9	0.61	-0.2	37.17	0.541	0.0016	2.5884

A declining value of M with age instead of a constant value was used based on the outcome of discussions held at SGMED-09-01, where the experts concluded such an approach is necessary considering the early age of first capture and the massive catch of juveniles characterised by higher M rates in most of the Mediterranean fisheries. Natural mortality rates by age were thus calculated according to the ProBiom model developed by Abella et al. (1997), based on Caddy (1991).

The values by age used in the analysis are given in Tab. 5.59.4.1.2.2. The age slicing in GSA 15 produced only 4 age groups (up age 3+).

Tab. 5.59.4.1.2.2. Values by age used for SURBA analyses for giant red shrimp (females) in GSAs 15 and 16.

Age	0	1	2	3	4	5+
Natural mortality at age	0.62	0.30	0.23	0.19	0.17	0.16
Maturità at age	0.00	1.0	1.0	1.0	1.0	1.0
Weight at age	10.44	34.95	56.48	70.97	79.72	85.5
Catchability coefficient	0.4	1.0	1.0	1.0	1.0	1.0

5.59.4.1.3. Results

State of adult / juvenile abundance:

Figures 5.59.4.1.3.1 and 5.59.4.1.3.2 combining GSAs indicate the stock to vary without an evident trend in the last year (2002-2007), although SSB reached its highest level in 2008 compared with the last 6 years.

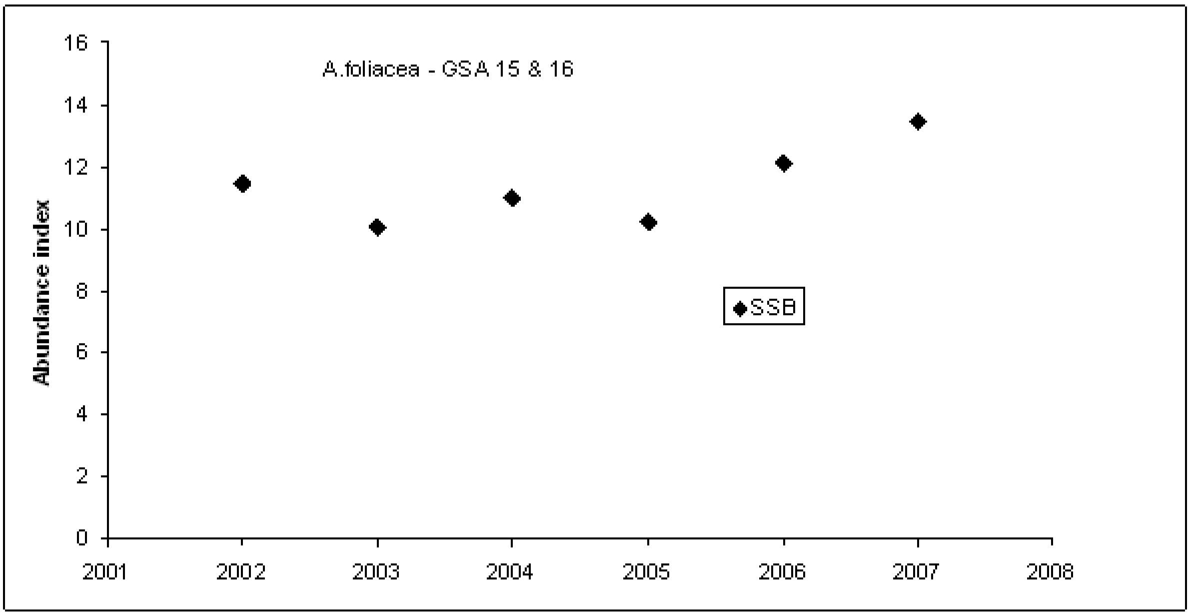


Fig. 5.59.4.1.3.1 SSB in kg/km^2 (MEDITS survey) in GSAs 15 and 16 from SURBA. Only slope grounds were considered (201-800 m).

Considering only the GSA 16 where the time series is longer (1994-2007), SSB shows stable low level since 2001.

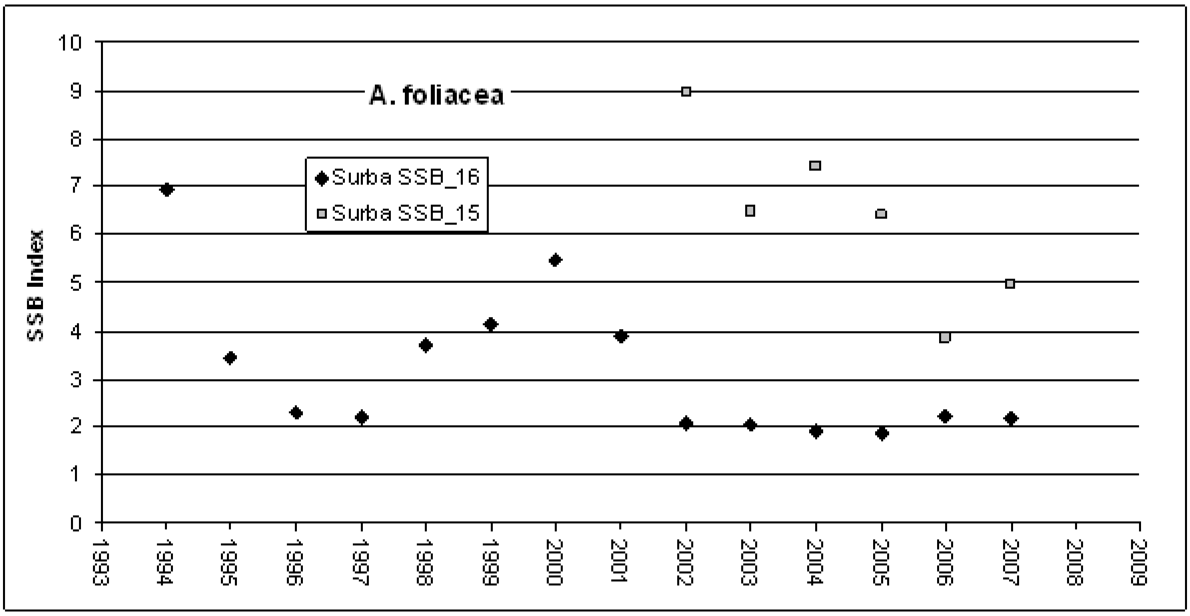


Fig. 5.59.4.1.3.2 SSB in kg/km^2 (MEDITS survey), as median of SURBA bootstrapped values, in GSAs 15 and 16. Only slope grounds were considered (201-800 m).

Survey indices in 2007 indicate the recruitment level to have recovered to average levels following a sharp drop in 2006 (Fig. 5.59.4.1.3.3 and 5.59.4.1.3.4).

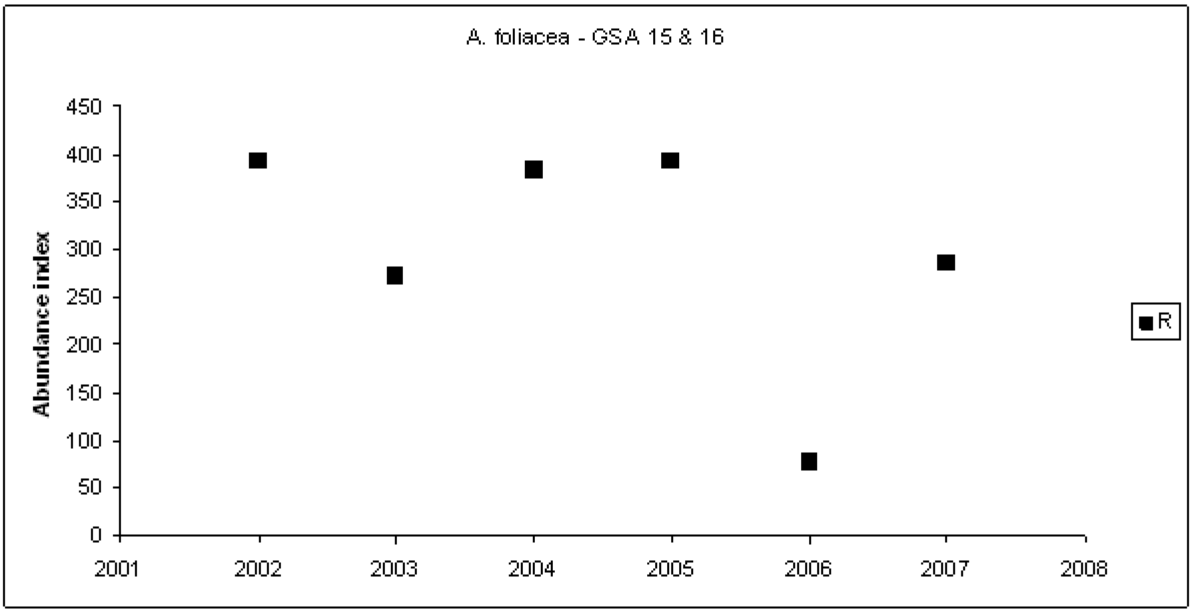


Fig. 5.59.4.1.3.3 Recruits n/km^2 (MEDITS survey) in GSAs 15 and 16 from SURBA analysis.

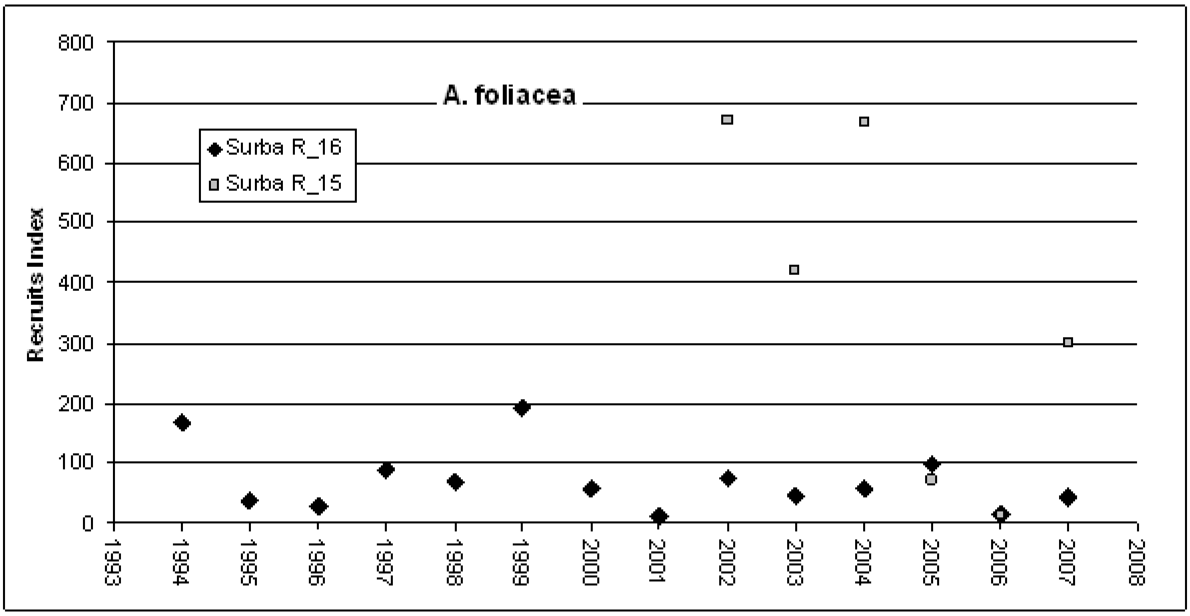


Fig. 5.59.4.1.3.4. Recruits n/km^2 (MEDITS survey), as median of SURBA bootstrapped values, in GSAs 15 and 16. Only slope ground was considered (201-800 m).

The stability of recruitment indices in the last years is also confirmed by the analysis of the longer series from GSA 16.

The values of F (age 1-3) in GSA 16 from 2000 to 2004 remains stable around 0.83 (SD=0.06). Time series from GSA 15 is still no long enough to evaluate any trend (Fig. 5.59.4.1.3.5.).

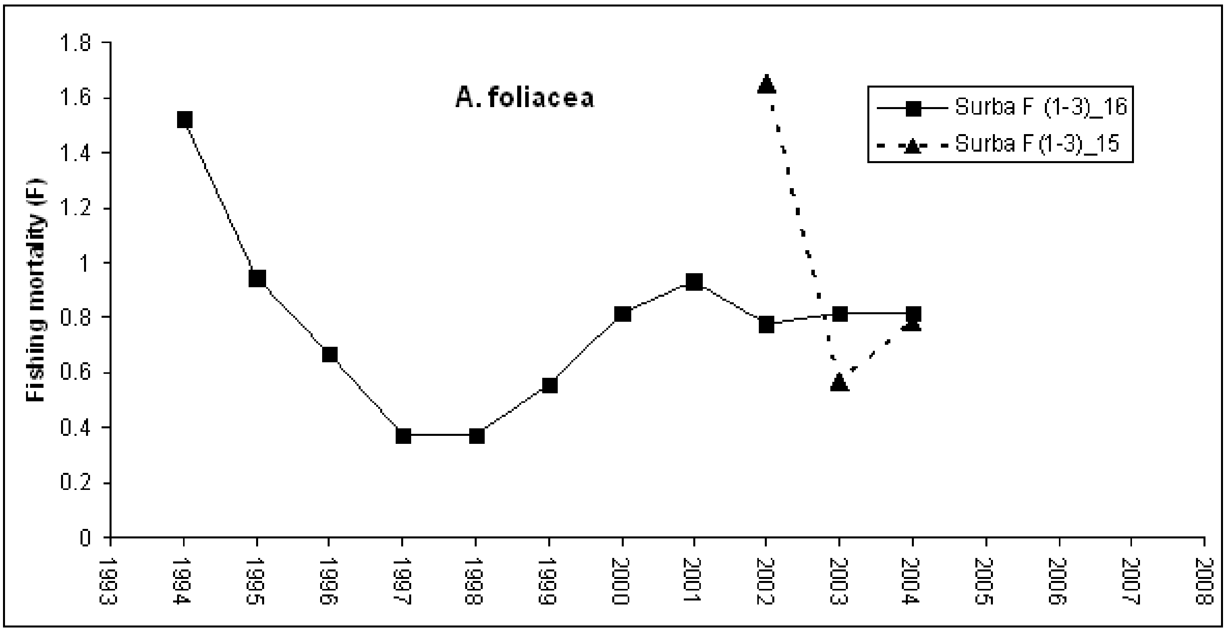


Fig. 5.59.4.1.3.5. Development of fishing mortality in GSAs 15 and 16.

5.59.4.2. Method 3: VIT

5.59.4.2.1. Justification

According to the SGMED-08-03, an approach assuming a steady state (pseudocohort) was used, keeping separate the available years (2006, 2007 and 2008). Cohort (VPA equation) and Y/R analysis as implemented in the package VIT4win were used (Lleonart and Salat, 2000). Data were derived from the DCR data call.

5.59.4.2.2. Input parameters

The parameters used in the analysis are reported in Tab. 5.59.4.2.2.1. No discard data were included as those were considered negligible. Analysis were carried out on the landings of the Italian trawlers which contribute to more than 97% of the total yield in the GSAs 15 and 16 (Tab. 5.59.2.3.1.1). Since females reach larger size than males and amount to more than 75% of landings in weight (Gancitano *et al.*, 2008), females parameters were used to asses stock exploitation.

Natural mortality and maturity by size are shown in Fig. 5.59.4.2.2.1.

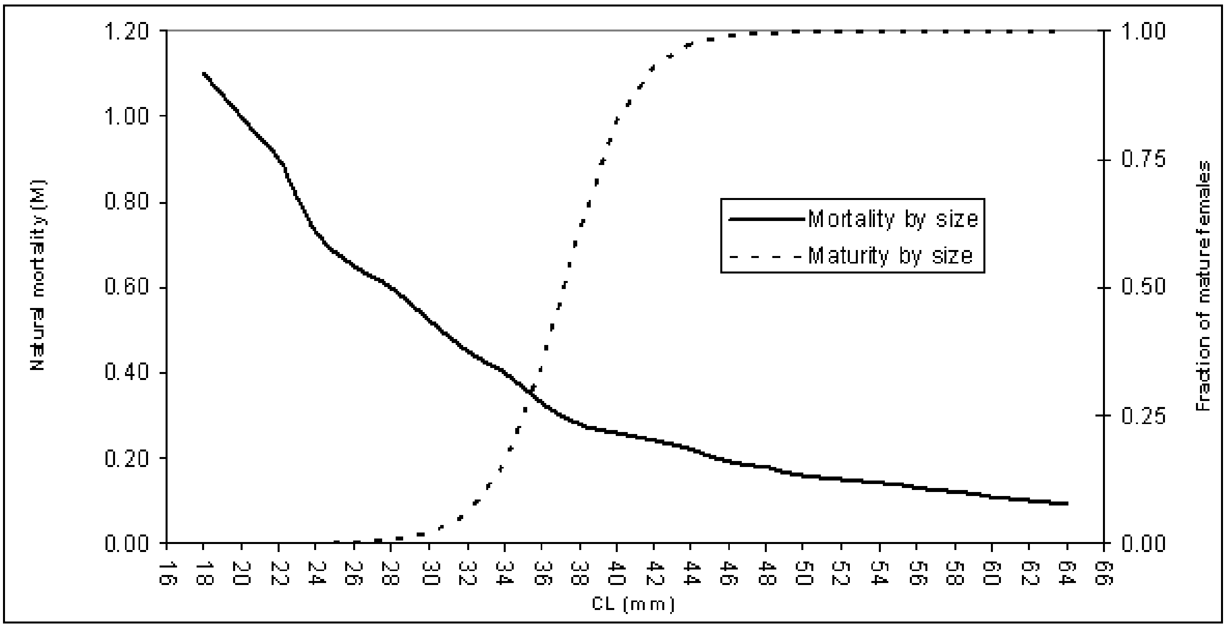


Fig. 5.59.4.2.2.1 Natural mortality (M) and maturity by length (CL) in females of giant red shrimp in the Strait of Sicily.

Tab. 5.59.4.2.2.1 Absolute number by length class (CL in mm) of females landed by year in the Strait of Sicily.

CL (mm)	2006	2007	2008
18	0	1147734	0
20	0	2127086	100309
22	237775	1890516	100309
24	772770	3623983	305050
26	475551	3149768	215550
28	118888	1318593	341753
30	127266	842297	256323
32	127266	532429	58259
34	31831	470665	41614
36	31831	408899	145916
38	379236	181206	243625
40	1142386	711999	327251
42	3044008	3151318	2740892
44	5496558	4435325	3064386
46	6012676	4454360	6327938
48	4499250	4313970	5444486
50	4328759	2964055	1190896
52	3934095	3878377	1051100
54	2702964	4481251	1845141
56	2027310	2456775	1555210
58	904016	962723	1846338
60	760428	761051	1128533
62	359591	574772	1515948
64	0	446168	712475
66	0	110053	101305
Total	37516461	49397379	30662613

5.59.4.2.3. Results

Fishing mortality rates (F) by size of female giant red shrimps caught by trawlers in GSAs 15 and 16 are shown in Fig. 5.59.4.2.3.1.

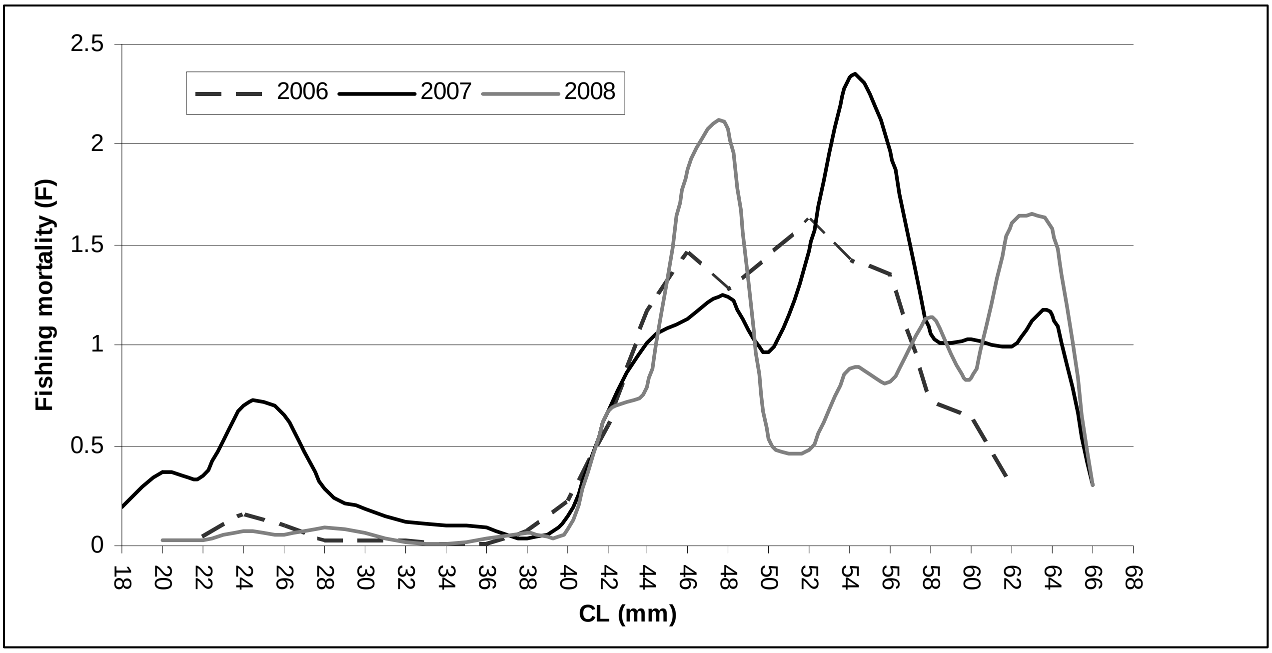


Fig. 5.59.4.2.3.1 Fishing mortality by size size of female giant red shrimps caught by trawlers in GSA 15 and 16.

The reconstructed yields obtained by the VIT package are virtually equal to the observed ones. Absolute recruitment estimation and other major results of the VIT analysis, including current mortality rates, are listed in Tab. 5.59.4.2.3.1.

Tab. 5.59.4.2.3.1. The main results of VIT analysis.

Year	2006	2007	2008	Median
Recostructed yield (t)	1424	1540	1260	1424
Biomass at sea (t)	1883	1825	1721	1825
SSB at sea (t)	1418	1307	1304	1307
Recruitment (ml)	73.8	95.3	62.8	73.8
Mean Z over all sizes	0.989	0.985	0.943	0.985
Mean F over all sizes	0.733	0.806	0.774	0.774
Mean F (1-3 age groups)	0.879	1.010	0.849	0.879

5.59.5. Long term prediction

5.59.5.1. Method 1: Y, B and SSB per recruit according to the VIT package

5.59.5.1.1. Justification

The VIT approach to Biomass and Yield per recruit analysis has been applied in order to analyse the stock production with increasing exploitation under equilibrium conditions.

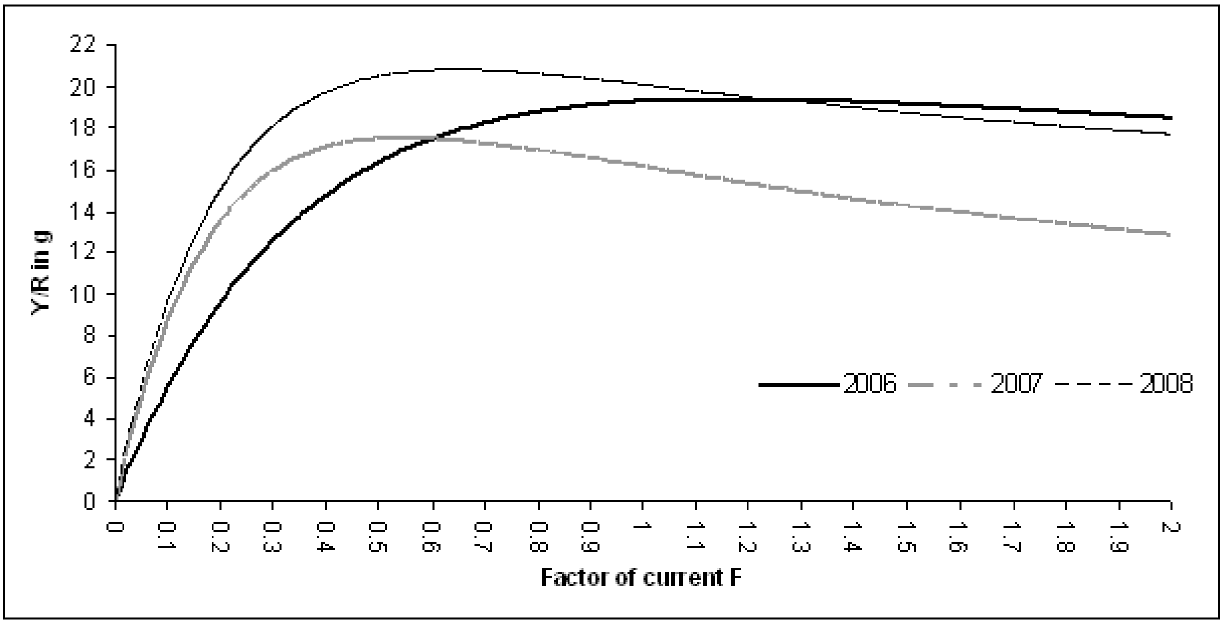


Fig. 5.59.5.1.1.1. Yield per recruit varying current fishing mortality (Fc) by a multiplicative factor according to the VIT package. Analyses deal with pseudo-cohorts 2006, 2007 and 2008.

Assuming no variation in the exploitation pattern, the main result of Y/R analysis in terms of current F and optimal ones are reported in Tab. 5.59.5.1.1.1.

Tab. 5.59.5.1.1.1 Estimation of current F, as F_{mean}, and optimal ones, as F_{max} and $F_{0.1}$, by pseudo cohorts according to VIT package. Median values are reported in bold.

Fishing mortalities	2006	2007	2008
Fcurrent	**0.774**	0.806	0.733
Fmax	0.913	0.451	**0.476**
F0.1	0.542	0.282	**0.293**

Comparing current F with BRP according to the obtained by VIT steady state VPA, a overfishing was clearly detected.

5.59.5.2. Method 2: Y, B and SSB per recruit according to the Yield package

5.59.5.2.1. Justification

Availability of biological parameter and length at first capture information allows the simulated quantification of likely changes in Y, B and SSB per recruit as a function of fishing mortality (F) with the

Yield package (Branch *et al.*, 2001). The package was also used to calculate a probability estimation of BRP (F_{max} and $F_{0.1}$).

5.59.5.2.2. *Input parameters*

All parameters were converted from Carapace Length (CL) in mm to Total Length (TL) by using the relation given by Gancitano (Pers. Com.):

TL (mm) = 2.678 CL (mm) + 28.564

The new parameters were subsequently converted in terms of cm and g. A guess estimate of uncertainty in terms of coefficient of variation was added to each parameter (Tab. 5.59.5.2.2.1). The natural mortality rate was assumed constant at M=0.40 (Ragonese *et al.*, 2004). Stock-recruitment relationship was not used, and instead recruitment was assumed to be constant with a random variability among years of CV=0.4.

Tab. 5.59.5.2.2.1. Parameters used for stock assessment through Yield approach. Lengths are in cm and weights in gr. Only the female fraction of the fished stock was assessed.

L∞	21.6 (0.1)	**Tm**	1 (0.1)
K	0.61 (0.1)	**Tc**	1 (0.1)
t0	-0.2 (0.1)	**M**	0.40 (0.1)
A	0.0034	**Recruitment**	Constant with CV=0.4
B	3.3562		

5.59.5.2.3. *Results*

Estimation of Y and SSB per recruit according to the Yield package are shown in Fig 5.59.5.2.3.1.

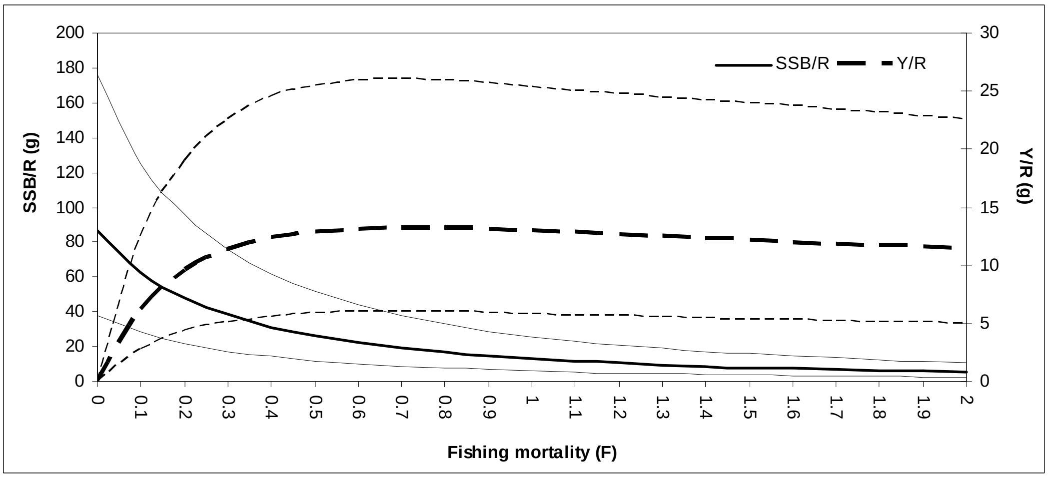


Fig. 5.59.5.2.3.1 Median of yield and spawning stock biomass per recruit and corresponding uncertainty of female giant red shrimp in the GSAs 15 and 16 according to the Yield Package.

Searching for biological reference points (BRP) through 2000 simulation produced the probability distribution of F_{max} and $F_{0.1}$ shown in Fig. 5.59.5.2.3.2.

The median value of F_{max} = 0.75 should be considered as Limit Reference Points (LRP) whereas the median value of $F_{0.1}$=0.4 should be considered as Target reference points (TRP).

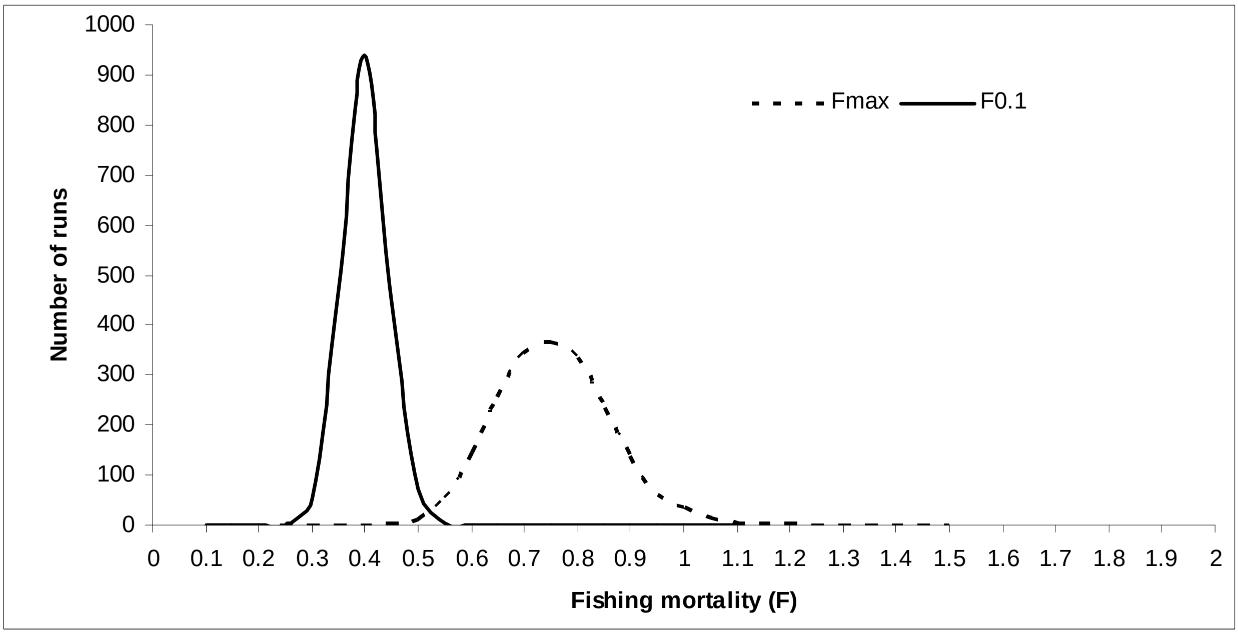


Fig. 5.59.5.2.3.2 Probability distribution of F_{max} and $F_{0.1}$ according to Yield package.

5.59.6. Scientific advice

5.59.6.1. Short term considerations

5.59.6.1.1. State of the spawning stock size

Absolute levels of stock abundance in 2006, 2007 and 2008 were estimated using the VIT approach on length structure of Sicilian trawlers which catch about 98% of the total yield in the area. Mean total biomass ranges between 1,721 t (2008) and 1,883 t (2006), being SSB about 75% of the total stock biomass.

Survey indices (MEDITS) combining GSAs indicate the stock to vary without an evident trend since 2002. However, the abundance and biomass of giant red shrimp consistently increased in both GSAs since 2007.

SGMED-10-02 cannot fully evaluate the state of the SSB due to the lack of precautionary management references.

5.59.6.1.2. State of recruitment

Absolute estimate of recruitment (18-22 mm CL) from VIT ranged between 63 (2008) and 95 (2007) millions of recruits. A low variability in recruitment indices derived from SURBA was observed when combining GSA data from 2002 to 2007, with the exception of sudden fall in recruit density observed in 2006 both in GSAs 15 and 16. The stability of recruitment indices in the last years is also confirmed by the analysis of the longer series from GSA 16.

5.59.6.1.3. State of exploitation

SGMED-10-02 proposes $F_{0.1}$=0.35 (average if both applied methods) as limit management reference point of exploitation consistent with high long term yield.

The giant red shrimp in the Northern sector of the Strait of Sicily is considered overfished until 2008 since the current fishing mortality is significantly higher than both F_{max} and $F_{0.1}$.

SGMED-10-02 recommends fishing mortality to be reduced by about 50% in order to avoid significant long term loss in potential yield. This should be realized by a multi-annual management plan reducing the fishing effort accordingly. It is advised to estimate the landings in accordance with the effort reductions.

SGMED-10-02 noted that the Italian government is adopting a management plan, in which a reduction of fishing mortality of 25% is planned within 2013. SGMED-10-02 supports the adoption of a management plan to continuously reduce current F through consistent effort reductions and catch estimations.

5.60. Stock assessment of giant red shrimp in GSA 19

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.60.1. Stock identification and biological features

5.60.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.60.1.2. Growth

No information was documented during SGMED-10-02.

5.60.1.3. Maturity

No information was documented during SGMED-10-02.

5.60.2. Fisheries

5.60.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.60.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.60.2.3. Catches

5.60.2.3.1. Landings

Table 5.60.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. The landings were mainly taken by demersal otter trawls.

Tab. 5.60.2.3.1.1 Annual landings (t) by fishing technique in GSA 19 as reported through the official DCF data call in 2010. No 2009 data were submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
ARS	19	ITA	GNS	DEMSP				1					
ARS	19	ITA	OTB	DWSP						37	97	66	
ARS	19	ITA	OTB	MDDWSP				62	55	200	102	67	
Sum								63	55	237	199	133	

5.60.2.3.2. Discards

According to information available to the SGMED-10-02 no catches of *Aristaeomorpha foliacea* were discarded by the Italian fleet.

5.60.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.60.2.3.3.1.

Tab. 5.60.2.3.3.1 Trends in annual fishing effort (kW*days) by fishing technique deployed in GSA 19, 2004-2008. No 2009 data were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
19	ITA				VL0006				0	1589	1289	
19	ITA				VL0612		43727	21997	57851	74979	39123	
19	ITA				VL1218		9424	43715	40060	28934	51895	
19	ITA	FPO	DEMSP		VL0612		25169	2690	3229	4066	4330	
19	ITA	FPO	DEMSP		VL1218		8894				52399	
19	ITA	GND	SPF		VL0006				0	0		
19	ITA	GND	SPF		VL0612		60866		4327	14947	13293	
19	ITA	GND	SPF		VL1218				6437	33090		
19	ITA	GNS	DEMSP		VL0006				0	2317	2514	
19	ITA	GNS	DEMSP		VL0612		42380	52151	52916	116463	56469	
19	ITA	GNS	DEMSP		VL1218		19276	5898	8441		3077	
19	ITA	GTR	DEMSP		VL0006				1576	0	3994	
19	ITA	GTR	DEMSP		VL0612		93233	21618	28909	49607	73983	
19	ITA	GTR	DEMSP		VL1218		37514		9694	22498	33993	
19	ITA	LHP-LHM	CEP		VL0612		0	0			901	
19	ITA	LLD	LPF		VL0006				0	0		
19	ITA	LLD	LPF		VL0612		21059	2262			1613	
19	ITA	LLD	LPF		VL1218		24556	11063		49548	86997	
19	ITA	LLD	LPF		VL1824		130836	29278	87254	162415	221621	
19	ITA	LLS	DEMF		VL0006				0	335	281	
19	ITA	LLS	DEMF		VL0612		32056	17304	941	31232	31930	
19	ITA	LLS	DEMF		VL1218		6788	25928	12992	30438	38940	
19	ITA	LLS	DEMF		VL1824		9101					
19	ITA	LTL	LPF		VL0612				2903			
19	ITA	OTB	DEMSP		VL1218		20694	128112			171458	
19	ITA	OTB	DEMSP		VL1824		45169				18603	
19	ITA	OTB	DWSP		VL1218					57896		
19	ITA	OTB	MDDWSP		VL1218		246735	207953	386565	396114	254049	
19	ITA	OTB	MDDWSP		VL1824		24687	97647	28684	44800	37335	
19	ITA	PS	LPF		VL1218				5610			
19	ITA	PS	SPF		VL0612			28041			6985	
19	ITA	PS	SPF		VL1218		94936		9833	49469	43538	
19	ITA	SB-SV	DEMSP		VL0612		17636					
19	ITA	SB-SV	DEMSP		VL1218		7479		25107		2220	
19	ITA	SB-SV	DEMSP		VL1824		33305					

5.60.3. Scientific surveys

5.60.3.1. Medits

5.60.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 19 the following number of hauls was reported per depth stratum (s. Tab. 5.60.3.1.1.1).

Tab. 6.60.3.1.1.1. Number of hauls per year and depth stratum in GSA 19, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA19_010-050	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9
GSA19_050-100	7	8	8	8	8	8	8	8	8	8	8	8	8	9	8	8
GSA19_100-200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	10
GSA19_200-500	16	15	15	15	15	15	15	15	21	21	14	15	14	14	14	14
GSA19_500-800	31	32	32	32	32	32	32	32	29	29	29	28	29	29	29	30

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai)\ /\ A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni)\ /\ A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length

frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.60.3.1.2. *Geographical distribution patterns*

No analyses were conducted during SGMED-10-02.

5.60.3.1.3. *Trends in abundance and biomass*

Fishery independent information regarding the state of the giant red shrimp in GSA 19 was derived from the international survey Medits. Figure 5.60.3.1.3.1 displays the estimated trend in giant red shrimp abundance and biomass in GSA 19.

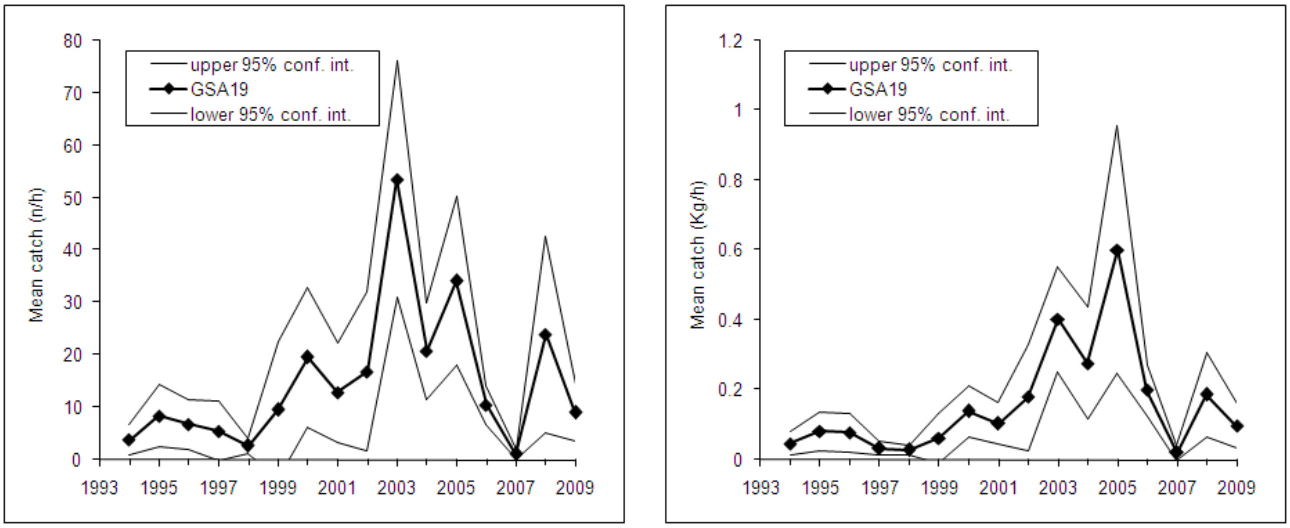


Fig. 5.60.3.1.3.1 Abundance and biomass indices of giant red shrimp in GSA 19.

5.60.3.1.4. *Trends in abundance by length or age*

The following Fig. 5.60.3.1.4.1 and 2 display the stratified abundance indices of GSA 19 in 1994-2009.

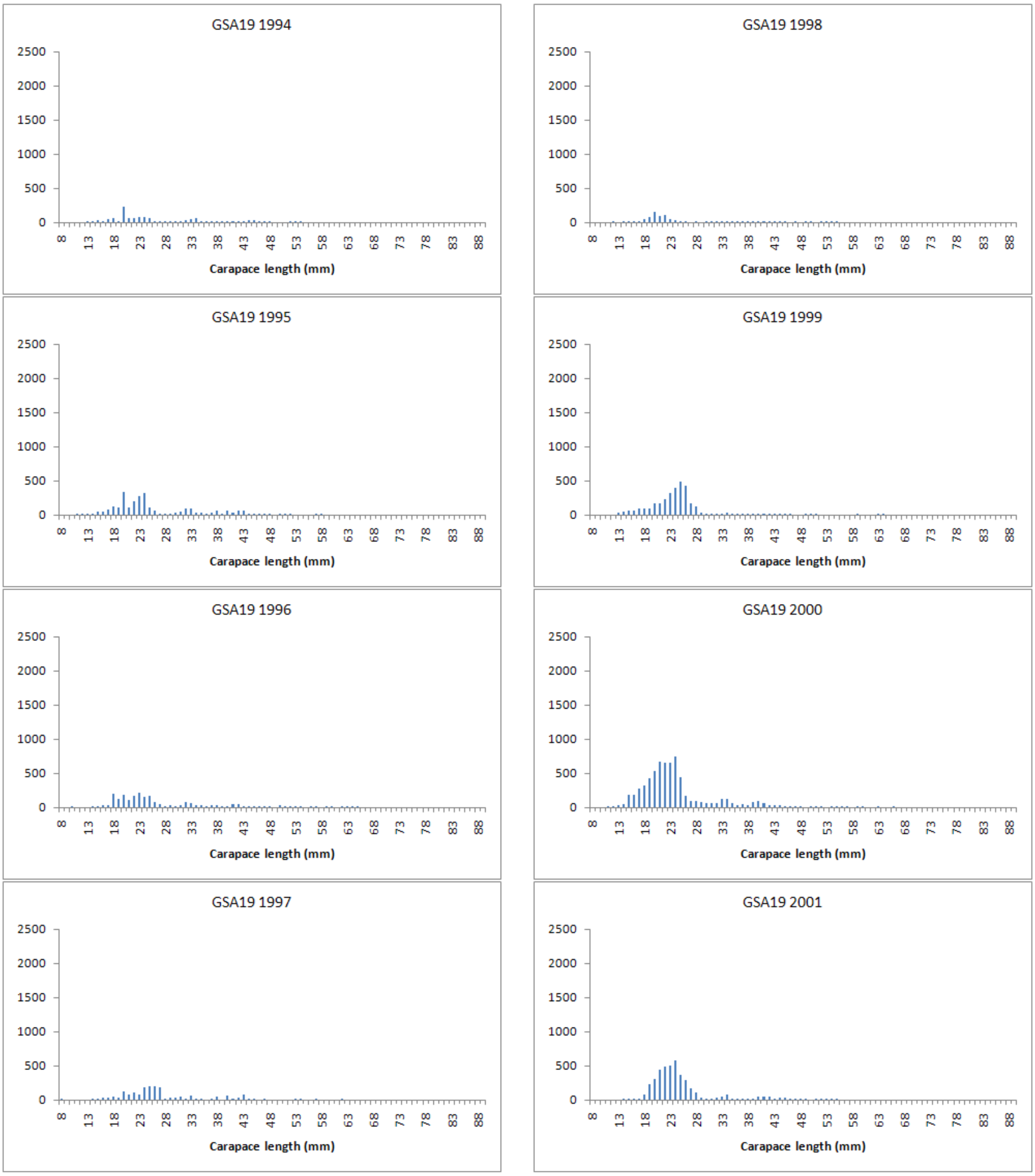


Fig. 5.60.3.1.4.1 Stratified abundance indices by size, 1994-2001.

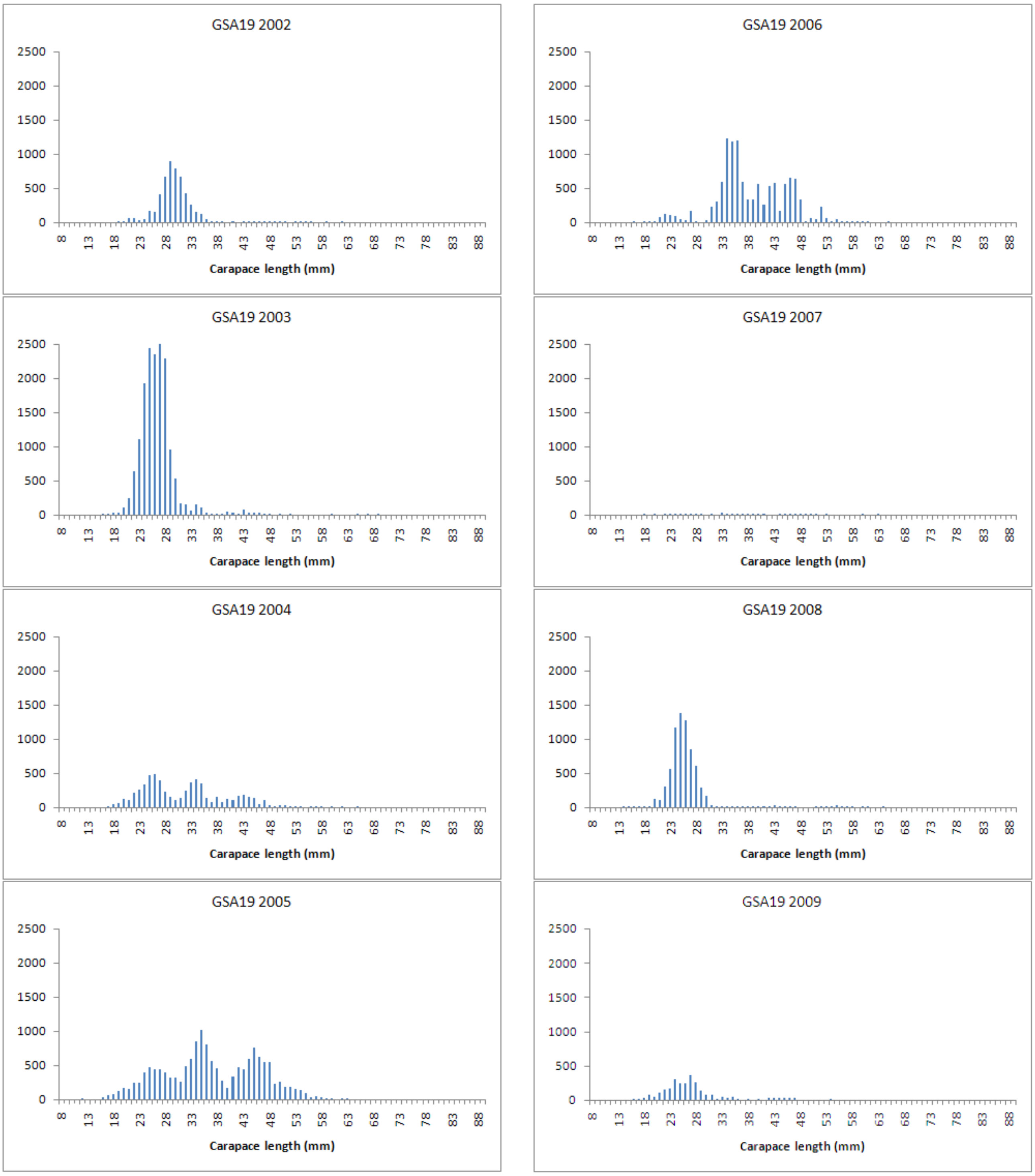


Fig. 5.60.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.60.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.60.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.60.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.60.5. Long term prediction

5.60.5.1. Justification

No forecast analyses were conducted.

5.60.5.2. Input parameters

No forecast analyses were conducted.

5.60.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for giant red shrimp in GSA 19.

5.60.6. Scientific advice

5.60.6.1. Short term considerations

5.60.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.60.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.60.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation given the preliminary state of the data and analyses.

5.61. Stock assessment of Norway lobster in GSA 05

5.61.1. Stock identification and biological features

5.61.1.1. Stock Identification

Due to the lack of information about the structure of Norway lobster (*Nephrops norvegicus*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 05 boundaries.

N. norvegicus is a mud-burrowing species that prefers sediments with mud mixed with silt and clay in variable proportions. The emergence of individuals from burrows may vary depending on biological features and environmental factors (moult or reproduction cycles, light intensity, etc).

5.61.1.2. Growth

The species shows a noticeable sexual dimorphism, with males reaching bigger sizes than females. Maximum observed size in GSA 05 was 80 mm CL for males and 65 mm CL for females. As there is not an estimation of growth parameters in the area, the used ones where those defined in the GSA 09:

L_∞ =72.1 (males) 56 (females)
K = 0.169 (males) 0.214 (females)
Length-weight relationship for both sexes: a = 0.00040, b = 3.126

5.61.1.3. Maturity

No information is available from this area, so the information provided from GSA 09 was used. Males reach maturity at 40.0 mm CL and females at 30.3 mm CL.Sex ratio is around 1:1 at around 23-24 mm CL. Below it, it is in favour of females and over it is in favour of males.

5.61.2. Fisheries

5.61.2.1. General description of fisheries

Norway lobster catches from the Balearic fleet comes exclusively from bottom trawl. The species is mostly caught in the upper slope (350-600 m). The mean annual number of days in which the fleet works in this fishing tactic (alone or in combination with other fishing tactics) is around 1050 days. Other species caught on the US are *Merluccius merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* (Guijarro and Massutí, 2006). Discards on the US have been estimated to be up to 18% (autumn) and 45% (spring) of captured biomass and they are composed by a large number of elasmobranchs, teleosts, crustaceans and cephalopods, among others.

5.61.2.2. Management regulations applicable in 2009 and 2010

- Fishing license: fully observed
- Engine power limited to 316 KW or 500 HP: not fully observed (in occasions, at least doubled)
- Mesh size in the codend (diamond 40 mm stretched): fully observed
- Time at sea (12 hours per day and 5 days per week): fully observed
- Minimum landing size (EC regulation 1967/2006, 20 mm CL): mostly fully observed

5.61.2.3. Catches

5.61.2.3.1. Landings

Landings of Norway lobster in GSA 05 come exclusively from trawling. In the last 8 years the total landings of *N. norvegicus* of GSA 05 oscillated around 20 tons (Fig. 5.61.2.3.1.1).

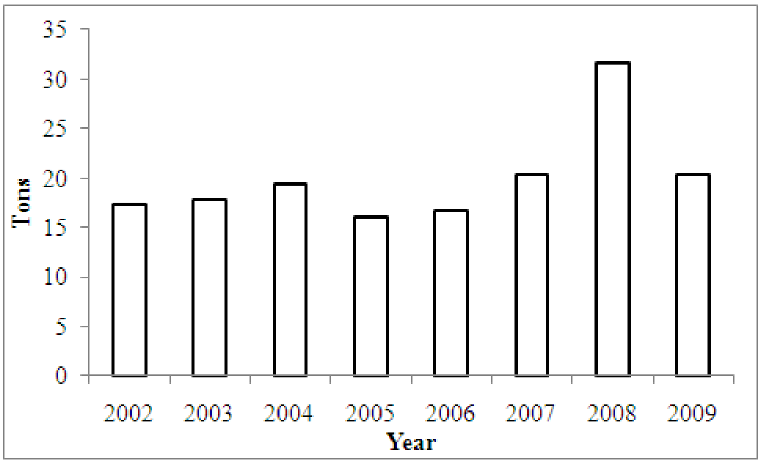


Fig. 5.61.2.3.1.1 Landings of Norway lobster (trawling) in the GSA 05, from 2002 to 2009 (DCR official data).

Landings are mostly composed by specimens from 25 to 45 mm CL (80% of the catches, Fig. 5.61.2.3.2).

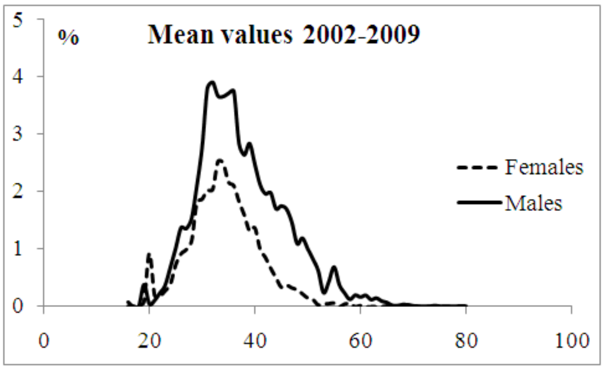


Fig. 5.61.2.3.1.2 Size structure of the landings of *N. norvegicus* in 2002-2009 (mean value) caught by otter trawling in the GSA 05 (DCR official data).

5.61.2.3.2. Discards

Discards of Norway lobster in GSA 05 can be considered as negligible. At the same time, the presence of specimens under the MLS (20 mm CL) in the landings is very scarce.

5.61.2.3.3. Fishing effort

Although there was a progressive diminution in the number of trawlers during the period 2000-2008, the total fishing effort remained rather constant because of the increase in vessel mean power (Fig. 5.61.2.3.3.1).

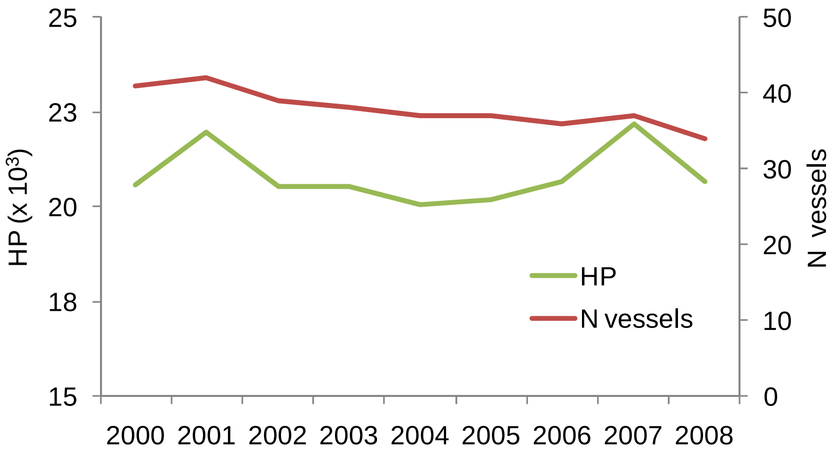


Fig. 5.61.2.3.3.1 Number of trawlers and total HP (mean HP x N of vessels) in Mallorca during 2000-2008.

5.61.3. Scientific surveys

5.61.3.1. BALAR and MEDITS surveys

5.61.3.1.1. Methods

From 2001, the Spanish Institute of Oceanography has performed annual bottom trawl surveys following the same methodology and sampling gear described in the MEDITS protocol.

5.61.3.1.2. Geographical distribution patterns

N. norvegicus is mostly distributed in the north of Mallorca and Menorca and in the south of Mallorca, where the main fishing grounds are sited.

5.61.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the *N. norvegicus* in GSA 05 was derived from the BALAR (2001-2006) and MEDITS (2007-2009) surveys. Fig. 5.61.3.1.3.1 displays the biomass trends in GSA 05. Biomass does not show any clear trend, with maximum values observed in 2002 and 2008.

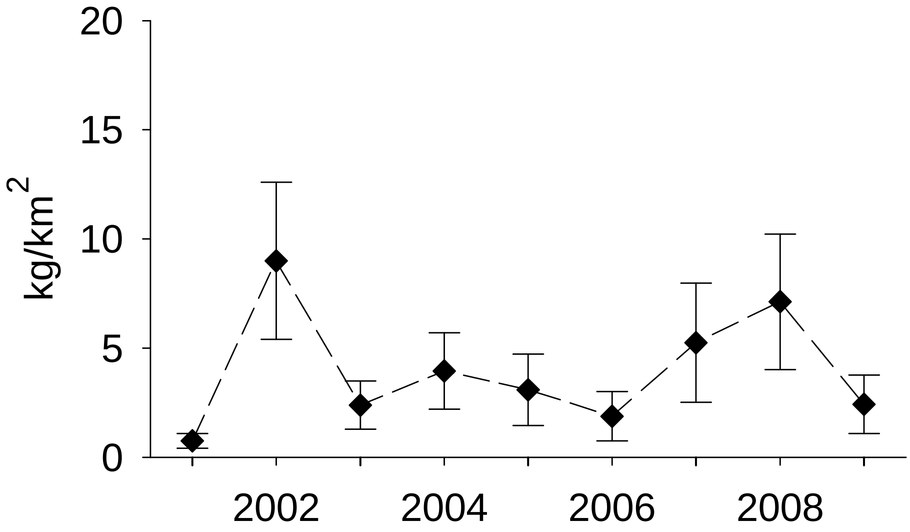


Fig. 5.61.3.1.3.1 Biomass indices of *Nephrops norvegicus* in GSA 05 from BALAR and MEDITS surveys.

5.61.3.1.4. Trends in abundance by length or age

No analyses were conducted during SGMED-10-02.

5.61.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.61.3.1.6. Trends in maturity

No analysis were conducted during SGMED-10-02.

5.61.4. Assessment of historic stock parameters

Although the assessment of Norway lobster from GSA05 has been already performed twice in the framework of the GFCM, it has been never accepted so this one can be considered the first assessment of this species in the area. As concern the SGMED-10-02, a new assessment was produced. The main results are presented below.

5.61.4.1. Method 1: VIT LCA

5.61.4.1.1. Justification

LCA analysis was performed using VIT program (Lleonart and Salat, 1992) using as input data the mean pseudo-cohort for the period 2002-2009 to provide a general overview of the current state of exploitation of Norway lobster in GSA 05. This analysis was followed by three other LCAs for three different years, one at the beginning of the data series (2002), one in the middle (2005) and the last one at the end (2009).

5.61.4.1.2. Input parameters

Tab. 5.61.4.1.2.1 Annual landings (t), 2002-2009 from Mallorca (GSA 05).

2002	2003	2004	2005	2006	2007	2008	2009
11.87	8.84	8.07	7.66	8.13	11.83	13.66	13.12

Tab. 5.61.4.1.2.2 Annual length distributions of landings, 2002-2009.

	2002	2003	2004	2005	2006	2007	2008	2009
16	0	0	0	0	0	0	2166	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	233	0	253	0
19	0	0	199	1605	0	0	1168	4310
20	0	0	973	0	233	0	2110	10187
21	0	0	588	490	0	2278	4400	308
22	0	151	2060	76	233	0	6915	837
23	399	88	2543	535	0	124	8543	2308
24	0	0	4184	1934	2492	1732	14129	2397
25	1555	705	9647	2933	820	5324	11898	6737
26	2189	2314	8116	3255	2951	1015	11048	14171
27	3804	4738	12502	3392	550	2399	17338	8653
28	6839	1646	6801	8390	550	992	17943	12807
29	14360	2316	13812	9030	3403	5765	19953	16735
30	16939	4848	19550	6935	5020	9994	20838	19222
31	26922	3630	19443	12947	10114	5421	27841	23302
32	29170	4479	15374	14634	14590	4887	24592	24407
33	28920	5614	13975	16244	12026	8462	21806	27676
34	27195	5403	15170	12455	14092	15556	24726	24588
35	23034	9274	9385	16979	19509	21877	22903	18652
36	12709	16300	7722	18630	14568	27357	20606	21158
37	14501	12979	13428	17197	9652	15484	16888	13390
38	19150	11255	9918	11726	12130	11792	14406	12259
39	11791	19419	15421	10008	8442	12059	11510	12404
40	7261	9884	9022	13472	12720	18980	16601	9613
41	8204	12480	7672	7997	9003	12477	12162	8080
42	11015	9625	6140	6001	12576	10672	9952	6309
43	10600	9203	9994	8421	14183	7111	7402	3807
44	10226	10502	5143	4298	6876	6938	5566	5544
45	8323	8167	4693	2957	10268	9550	10261	2526
46	15172	5991	3498	6352	6208	5687	7721	2926
47	7287	7317	2103	4217	9968	6960	8136	2398
48	5033	5981	2203	3386	6435	6304	5203	2323
49	2905	4251	3747	717	3926	18507	5121	1201
50	2343	2440	2202	6544	2718	8364	3630	2162
51	2563	5013	1412	1864	3446	5759	3402	1721
52	2381	3404	1994	0	537	2713	1728	2422
53	528	492	748	1697	2401	1439	1135	0
54	1050	1413	1015	0	4130	2349	2470	807
55	1892	308	4144	1493	1479	3522	3939	1899
56	483	187	1527	1295	687	2352	1537	1151
57	227	490	868	1302	169	2433	2224	112
58	91	351	493	999	0	77	773	885
59	0	654	170	0	1479	1634	84	830
60	876	725	30	0	1102	1104	789	262
61	218	725	157	0	304	231	3219	193
62	0	374	240	490	0	77	1116	385
63	0	1204	43	76	0	461	1757	214
64	0	187	0	0	0	1360	691	193
65	302	165	0	0	0	1149	287	193
66	122	0	57	0	0	0	286	0
67	0	356	30	0	0	0	5	0
68	0	0	0	0	518	0	0	193
69	302	0	57	0	169	274	25	0
70	122	0	30	0	0	63	40	0
71	0	0	57	0	0	0	0	0
72	0	0	30	0	0	0	5	0
73	0	0	0	0	0	0	0	0
74	0	0	0	0	0	411	0	0
75	0	0	0	0	0	95	15	0
76	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0
79	0	0	0	0	0	274	0	0
80	0	0	0	0	0	63	10	0

Biological parameters used correspond to those available from GSA 09. There are no catches for age 0.

Tab. 5.61.4.1.2.3 Biological input parameters.

Mean weight in catch									
0	1	2	3	4	5	6	7	8	9+
0	0.0035	0.0116	0.0216	0.0349	0.052	0.0695	0.0869	0.1042	0.1238

Growth parameters			
Sex	L_8	k	t_0
F	56 mm	0.214 y^{-1}	-
M	72.1	0.169 y^{-1}	-

Length-weight relationship	
a	b
0.00040	3.126

Maturity oogive										
Age	0	1	2	3	4	5	6	7	8	9+
Prop. Matures	0	0.2	0.5	0.9	1	1	1	1	1	1

Natural mortality (PROBIOM; Abella et al., 1997)										
Age	0	1	2	3	4	5	6	7	8	9+
M	1.004	0.579	0.387	0.277	0.227	0.202	0.188	0.178	0.172	0.166

5.61.4.1.3. Results

The general results of LCA (Fig. 5.61.4.1.3.1.) show mean values of F ranging from 0.2 to 0.8. Population results from the different LCAs did not show any differences.

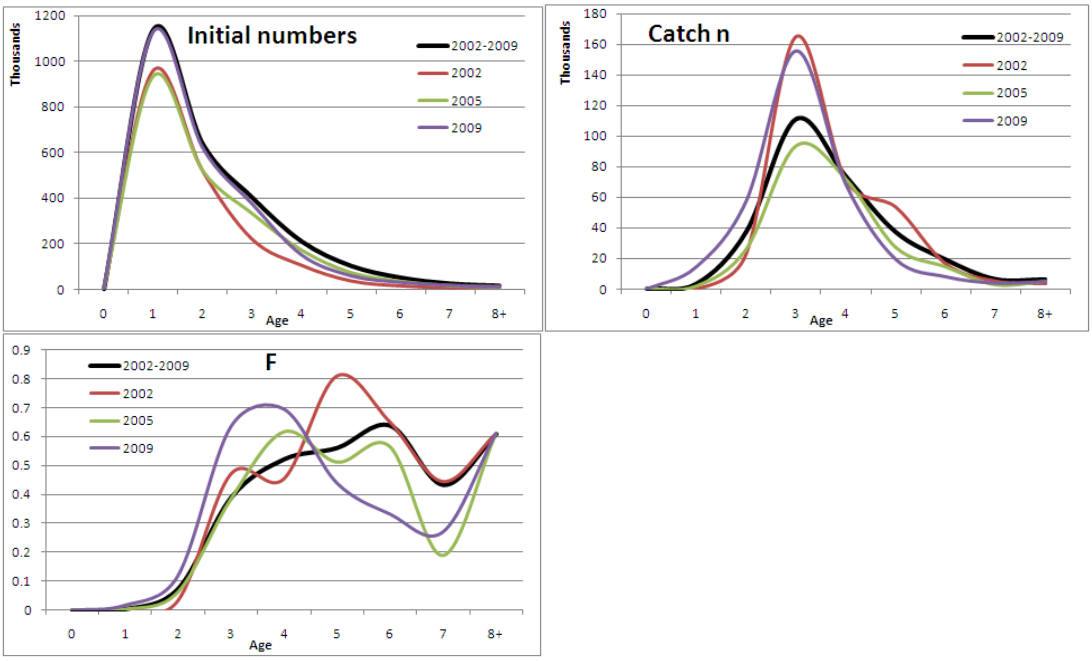


Fig. 5.61.4.1.3.1. LCA outputs: catch numbers, numbers-at-age and fishing mortality at age of *N. norvegicus* in GSA 05.

Table 5.61.4.1.3.1 VIT results (recruits, SSB, F) for 2002, 2005, 2009.

	2002	2005	2009
Recruits (millions)	0.960	0.934	1.128
SSB (t)	6.82	12.50	11.84
F	0.496	0.368	0.389

5.61.5. Long term prediction

5.61.5.1. Justification

A yield per recruit analysis was conducted.

5.61.5.2. Input parameters

Minimum and maximum ages for the analysis were 2 and 5 years, respectively. Stock weight at age and catch weight at age were estimated as mean values on a long term basis (2000-2009). Natural mortality by age was from PROBIOM (Abella et al. 1997) as recommended in the report of the SG-ECA/RST/MED-09-01. Reference F was considered to be the mean F for ages 2 to 5.

5.61.5.3. Results

The reference fishing mortality (F_{ref}) is displayed in Tab. 5.61.5.3.1, along with the reference points $F_{0.1}$ and F_{max}. Fig. 5.61.5.3.1 shows the results of the yield per recruit analysis.

Tab. 5.61.5.3.1 Resulting parameters from the YpR analysis.

	F
$F_{0.1}$	0.4209
F_{max}	0.9089
F_{ref}	0.6175

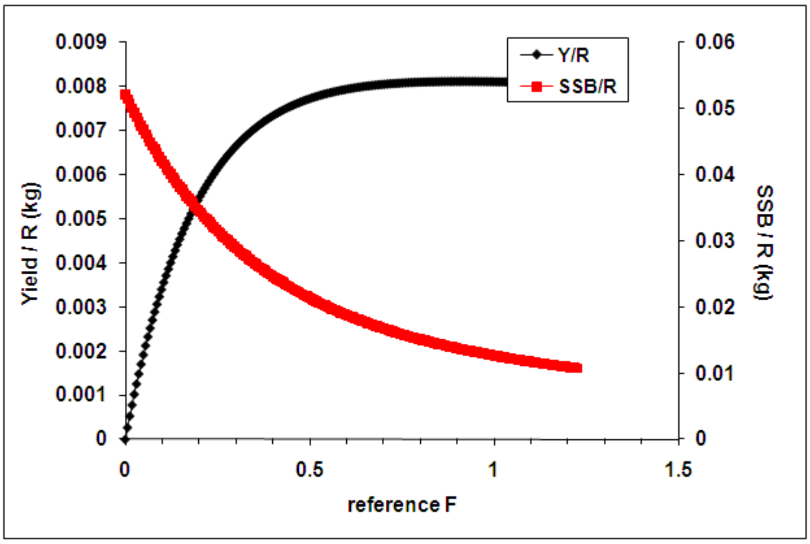


Fig. 5.61.5.3.1 Long term Yield and SSB per recruit with increasing fishing mortality.

5.61.6. Data quality

Data from Spain was not submitted on time through the Official Data call but only sent by email later on and therefore were not accepted. The assessment was carried out with data from the Spanish Data Collection Program.

5.61.7. Scientific advice

5.61.7.1. Short term considerations

5.61.7.1.1. State of the spawning stock size

SSB increased over the years 2002, 2005 and 2009, from the beginning of the data series (around 7 t) to the most recent years (around 12 t). In the absence of proposed and agreed precautionary management reference points SGMED is unable to fully evaluate the state of the stock.

5.61.7.1.2. State of recruitment

Number of recruits for the years 2002, 2005 and 2009 were estimated to be rather constant with around 1 million individuals for the three years analysed.

5.61.7.1.3. State of exploitation

SGMED-10-02 recommends $F_{0.1}$=0.42 as limit management reference point consistent with high long term yields.

The F_{ref} (0.62) exceeds the Y/R $F_{0.1}$ reference point (0.42), which indicates that Norway lobster in GSA 05 is overexploited in the long term.

5.62. Stock assessment of Norway lobster in GSA 09

5.62.1. Stock identification and biological features

5.62.1.1. Stock identification

Due to a lack of information about the structure of Norway lobster (*Nephrops norwegicus*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 09 boundaries. Adults tend to be territorial, with limited migration. However, transferal of larvae between areas may occur.

N. norvegicus is a mud-burrowing species that prefers sediments with mud mixed with silt and clay in variable proportions. The emergence from burrows of individuals may vary depending on biological features or environmental factors (moult or reproduction cycles, light intensity, etc).

The species lives on muddy substrates at depths between 150 and 800 m, but in the area is more commonly found between 250 and 800 m depth (Biagi *et al*., 2002; Colloca *et al*., 2003).

Recruits peak in abundance between 400 and 500 m depth over the upper slope and appear to move slightly deeper when they reach 30 mm carapace length (Fig. 5.62.1.1.1).

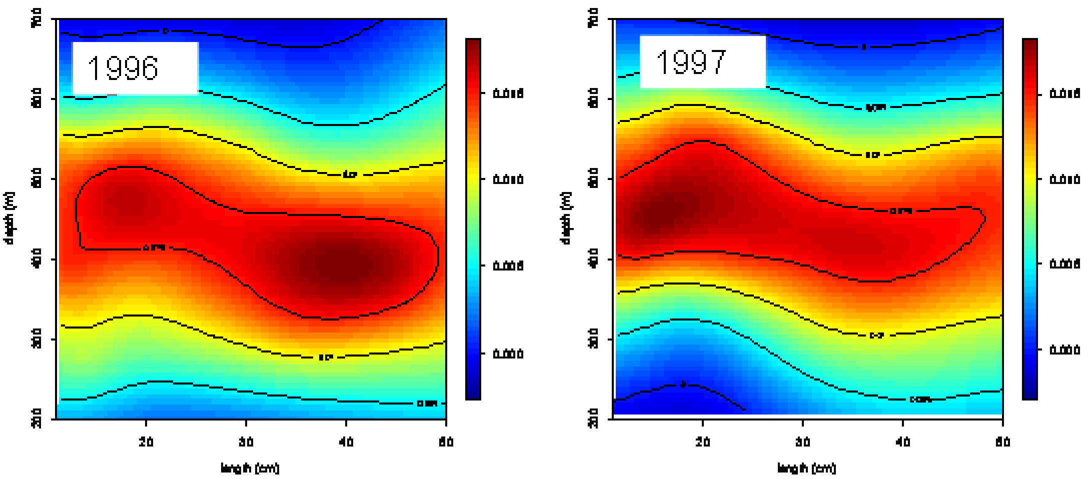


Fig. 5.62.1.1.1 Size-depth distribution of Norway lobster in the GSA 09 in 1996 and 1997 (GRUND survey).

5.62.1.2. Growth

The species shows a noticeable sexual dimorphism, with males that reach bigger sizes than females. Maximum observed size in the GSA 09 was 72 mm CL for males and 57 mm CL for females.
Growth parameters defined in the area were:
L_∞ =72.1 (males) 56 (females)
K = 0.169 (males) 0.214 (females)
Length-weight relationship for both sexes: a = 0.00040, b = 3.126

5.62.1.3. Maturity

Males reach maturity at 40 mm CL and females at 30.3 mm CL. Sex ratio is about 1:1 until 26 mm CL; in favour of females from 26 to 35 mm CL; in favour of males from 38 mm CL (De Ranieri *et al*., 1996). Reproduction peak is between spring and summer, and females with external eggs are observed in autumn-winter.

5.62.2. Fisheries

5.62.2.1. General description of fisheries

Norway lobster is one of the most important components of bottom trawlers catch in the GSA 09, as total annual value of the landings.

The trawlers fleet of GSA 09 at the end of 2006 accounted for 361 vessels (Tab. 5.62.2.1.1). From those vessels, only a fraction targets *Nephrops norvegicus.*

The main trawl fleets of GSA 09 are present in the following continental harbours: Viareggio, Livorno, Porto Santo Stefano (Tuscany), Fiumicino, Terracina, Gaeta (Latium).

Tab. 5.62.2.1.1 Technical characteristics of the trawl fleet of GSA 09 (year 2007, DCR official data).

N. of boats	361
GT	13.191
kW	75.514
Mean GT	36.5
Mean kW	209.2

The majority of bottom trawlers of GSA 09 operates daily fishing trips with only some vessels able to stay out of the port for two-three days especially in summer.

Norway lobster fishing grounds include soft bottoms of upper slope, generally between 350 and 600 m depth. Fishing pressure shows some geographical differences inside the GSA 09 according to the consistency of the fleets, the availability of the resources and the morphology of the continental shelf and upper slope. The species by-catch is mainly represented by *Micromesistius poutassou, Phycis blennoides, Lepidorhombus bosci, Galeus melastomus, Parapenaeus longirostris, Eledone cirrhosa, Todaropsis eblane, Trachurus spp.*

5.62.2.2. Management regulations applicable in 2009 and 2010

- Fishing closure for trawling: 45 days in late summer (not every year have been enforced).
- Minimum landing sizes: EC regulation 1967/2006: 20 mm CL for Norway lobster.
- Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 01/06/2010 the existing nets will be replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

5.62.2.3. Catches

5.62.2.3.1. Landings

Landings of Norway lobster in GSA 09 are almost exclusively provided by trawling (Tab. 5.62.2.3.1.1). In the last five years the total landings varied between 228 and 289 tons (Fig. 5.62.2.3.1.1).

Tab. 5.62.2.3.1.1 Landings (t) of Norway lobster in GSA 09 by fishing technique as officially reported through the 2010 DCF data call. No data for 2009 were reported by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
NEP	9	ITA						5	2	1			
NEP	9	ITA	FPO	DEMSP								0	
NEP	9	ITA	GNS	DEMSP				0	0	0		0	
NEP	9	ITA	GNS	SLPF								0	
NEP	9	ITA	GTR	DEMSP					0				
NEP	9	ITA	LLD	LPF				0	0				
NEP	9	ITA	OTB	DEMSP				76	14	18	45	143	
NEP	9	ITA	OTB	DWSP								1	
NEP	9	ITA	OTB	MDDWSP				193	273	229	215	84	
NEP	9	ITA	PS	SPF				0					
Sum								274	289	248	260	228	

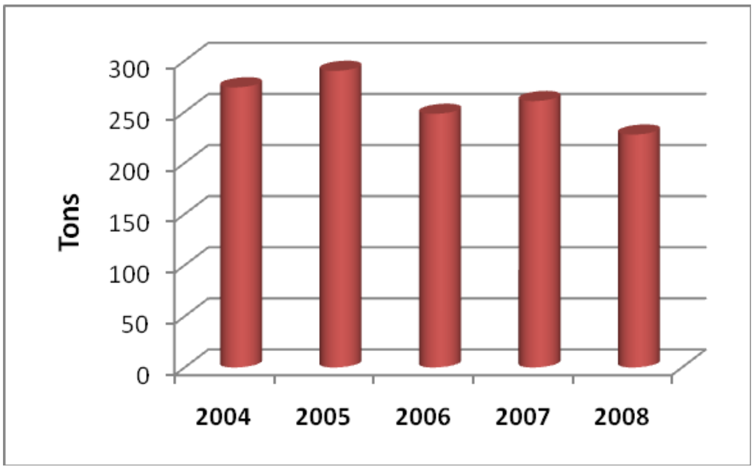


Fig. 5.62.2.3.1.1 Landings of Norway lobster in the GSA 09, from 2004 to 2008 (DCR official data).

Landings are mostly composed by specimens from 25 to 50 mm CL (Fig. 5.62.2.3.1.2) which correspond to individuals over 2+. Due to the sexual dimorphism of the species, the majority of the specimens greater than 40 mm CL are males. Landings from 2009 were not submitted by the Italian authorities.

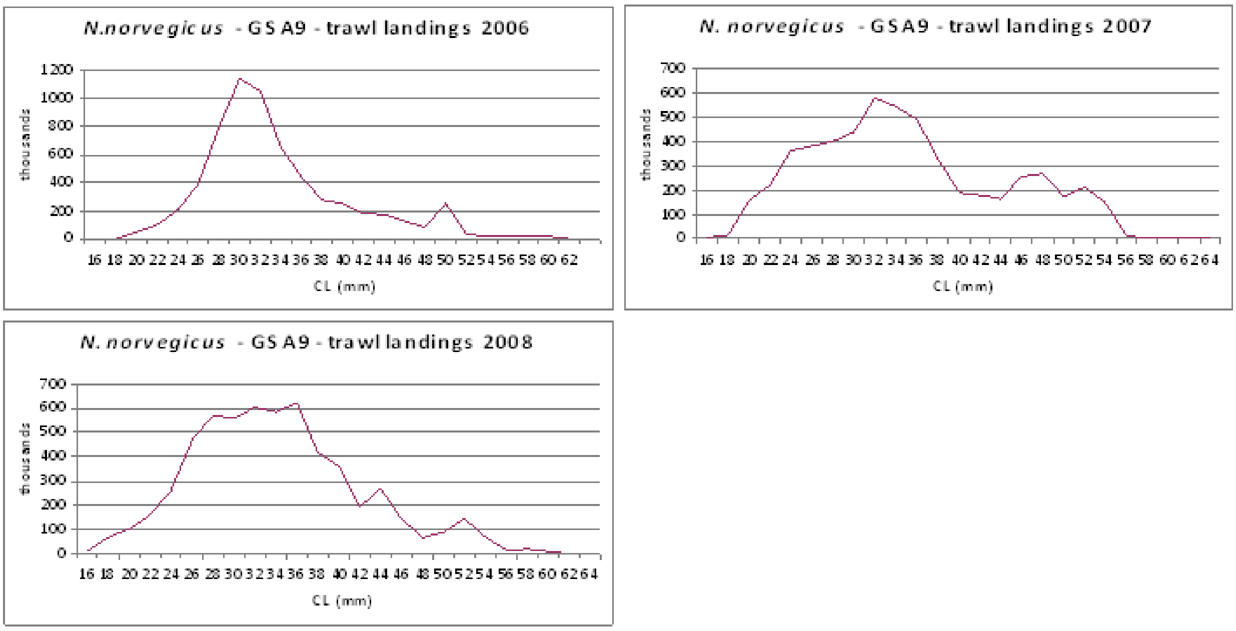


Fig. 5.62.2.3.1.2 Size structure of the landings of *N. norvegicus* in 2006-2008 caught by otter trawling in the GSA 09 (DCR official data).

5.62.2.3.2. *Discards*

Several EU and national projects carried out in GSA 09 highlighted that discard of Norway lobster in GSA 09 is negligible. At the same time, the presence of specimens under the MLS (20 mm CL) in the landings is very scarce. The same picture was obtained during the monitoring of discard performed in the 2006 DCR.

5.62.2.3.3. *Fishing effort*

The fishing capacity of the GSA 09 has shown in these last 10 years a progressive decrease. From 1996 to 2006 the number of bottom trawlers of GSA 09 decreased of about 30%. Data of fishing effort from 2009 were not submitted by the Italian authorities.

The total fishing days carried out by all the GSA 09 trawlers varied from about 65,000 in 2004 to about 63,000 in 2006 (Fig. 5.62.2.3.3.1). A little decrease of the mean number of fishing days/year per vessel was observed in this period, from 187 to 177. Anyway, there is no information on the specific effort directed to *N. norvegicus* in GSA 09.

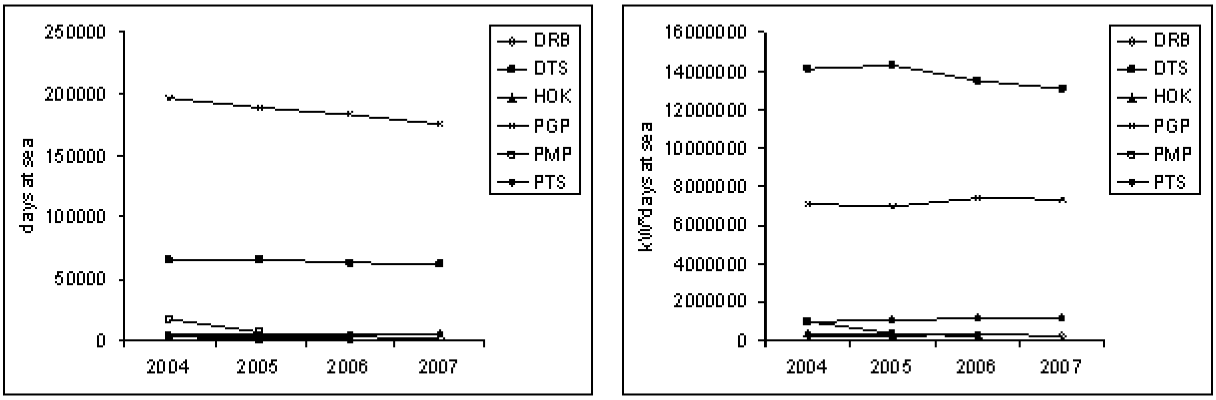


Fig. 5.62.2.3.3.1 Effort trends (days and kW*days) in 2004-2007 by major fleets for GSA 09.

Fig. 5.62.2.3.3.1 Effort trends (kW*days) in GSA 09 as reported through the official 2010 DCF data call. No data for 2009 were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
9	ITA				VL0006					296		
9	ITA				VL0612		31025	45782	71302	4865	12129	
9	ITA	DRB	MOL		VL1218		18652	20370	13504	29808	28266	
9	ITA	GNS	DEMSP		VL0006				14365	9687	7681	
9	ITA	GNS	DEMSP		VL0612		204925	219978	146971	201390	146006	
9	ITA	GNS	DEMSP		VL1218		100498	59006	49194	62666	67944	
9	ITA	GNS	SLPF		VL0612		4857				3707	
9	ITA	GTR	DEMSP		VL0006				1417	4451		
9	ITA	GTR	DEMSP		VL0612		75571	121141	100767	142363	43116	
9	ITA	GTR	DEMSP		VL1218		3222	19168	11102	14510	6610	
9	ITA	LLD	LPF		VL0612		6569	17394	3581	5904	25890	
9	ITA	LLD	LPF		VL1218		1611	4427	24956	5535	12094	
9	ITA	LLS	DEMF		VL0612		37454	75215	18823	4330		
9	ITA	LLS	DEMF		VL1218		3914	9998				
9	ITA	LTL	LPF		VL0006				3198	687		
9	ITA	OTB	DEMSP		VL0612		7282	6524	15126	21176	14595	
9	ITA	OTB	DEMSP		VL1218		118419	113284	77407	171295	221969	
9	ITA	OTB	DEMSP		VL1824		515183		69690	200680	478813	
9	ITA	OTB	DEMSP		VL2440		125282					
9	ITA	OTB	MDDWSP		VL1218		151739	183842	177083	158561	57869	
9	ITA	OTB	MDDWSP		VL1824		85625	737780	692516	404814	75728	
9	ITA	PS	SPF		VL0612			10014				
9	ITA	PS	SPF		VL1218			3703				
9	ITA	PS	SPF		VL1824		6526	6055				
9	ITA	SB-SV	DEMSP		VL0006				3780	3664	4506	
9	ITA	SB-SV	DEMSP		VL0612		127810	191056	133213	74903	62000	
9	ITA	SB-SV	DEMSP		VL1218		22438	10582	13566	2988	5196	

5.62.3. *Scientific surveys*

5.62.3.1. MEDITS

5.62.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 09 the following number of hauls was reported per depth stratum (s. Tab. 5.62.3.1.1.1).

Tab. 5.62.3.1.1.1. MEDITS survey. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA09_010-050	19	18	18	18	19	18	18	18	13	13	13	14	13	13	13	14
GSA09_050-100	19	20	18	19	18	19	20	20	15	15	15	14	16	16	13	14
GSA09_100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	28	27
GSA09_200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	30	28
GSA09_500-800	31	30	31	28	30	28	27	29	24	22	21	20	20	17	18	20

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

5.62.3.1.2. Geographical distribution patterns

Norway lobster is distributed in the whole GSA with the highest abundance in the south Ligurian Sea and northern Tyrrhenian Sea.

5.62.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the *N. norvegicus* in GSA 09 was derived from the international survey MEDITS. Figure 5.62.3.1.3.1 displays the re-estimated trend in *N. norvegicus* abundance and biomass in GSA 09 based on the DCR data call. While there appears no overall trend evident both indices of abundance and biomass in 2009 represent the maximum since 1994.

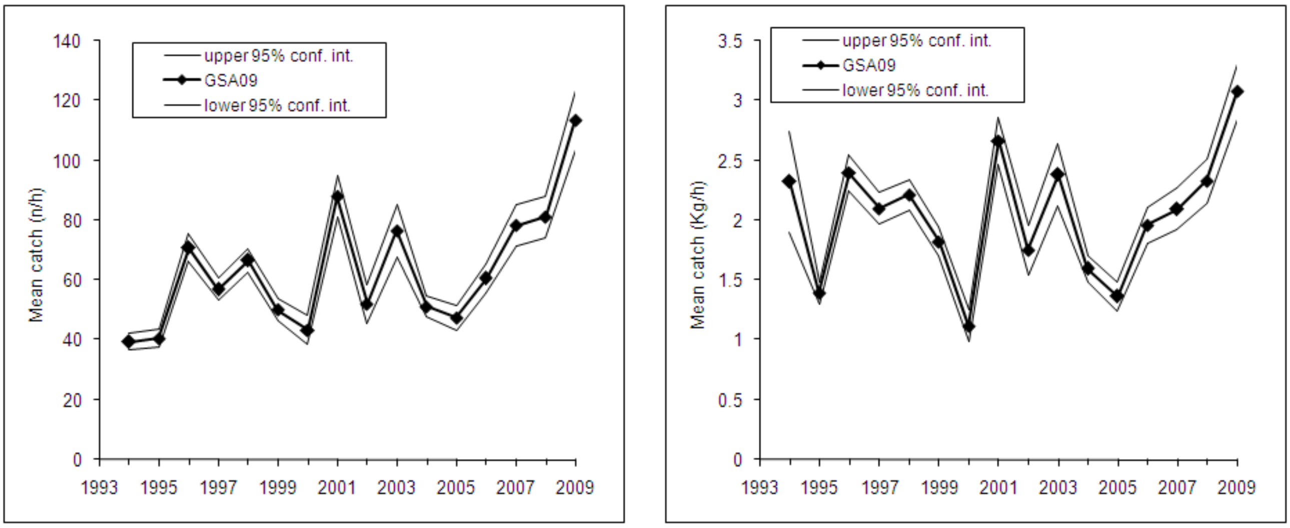


Fig. 5.62.3.1.3.1 Abundance and biomass indices of *Nephrops norvegicus* in GSA 09.

5.62.3.1.4. Trends in abundance by length or age

The following Fig. 5.62.3.1.4.1 and 2 display the stratified abundance indices of GSA 09 in 1994-2001 and 2002-2009.

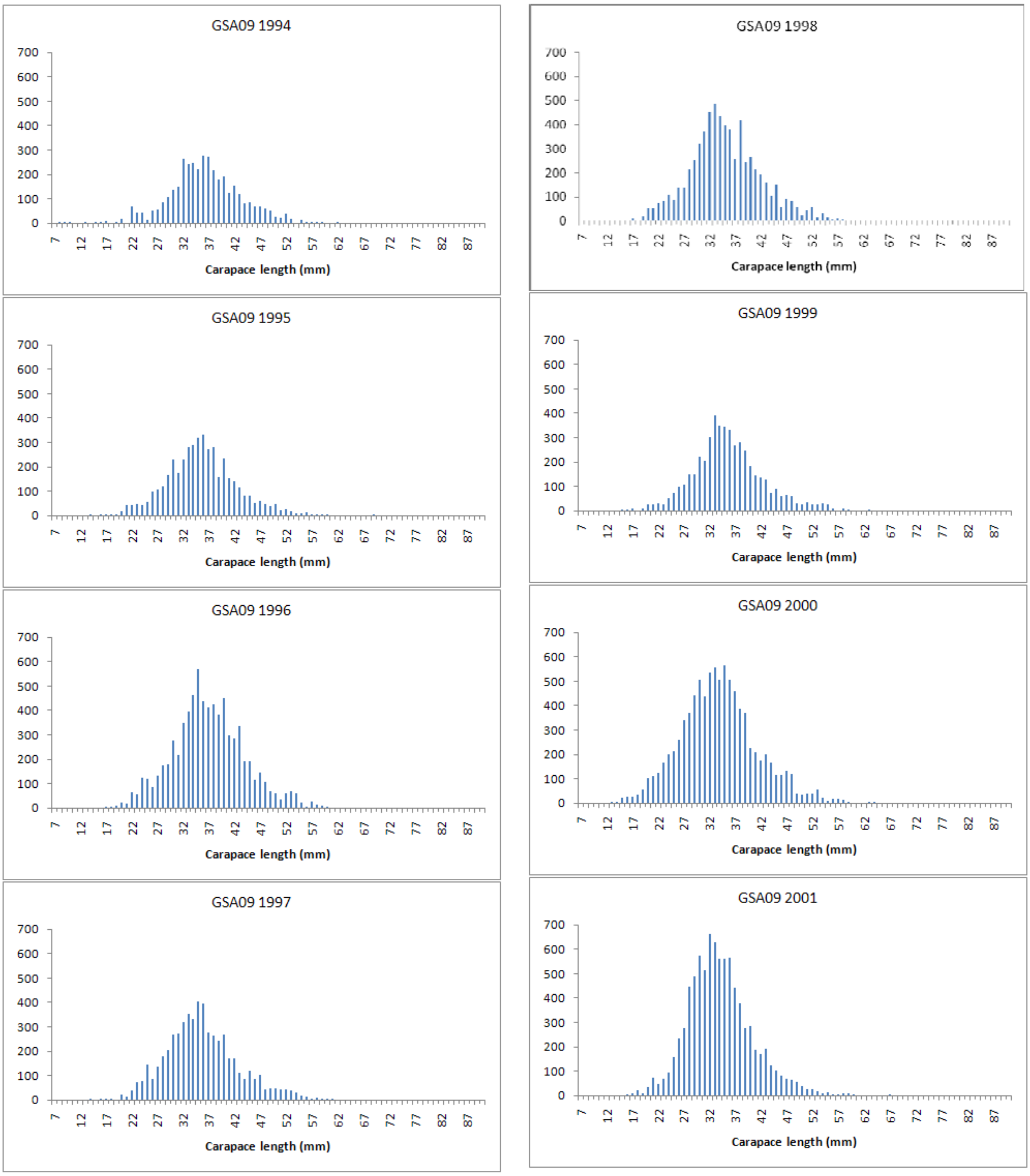


Fig. 5.62.3.1.4.1 Stratified abundance indices by size, 1994-2001.

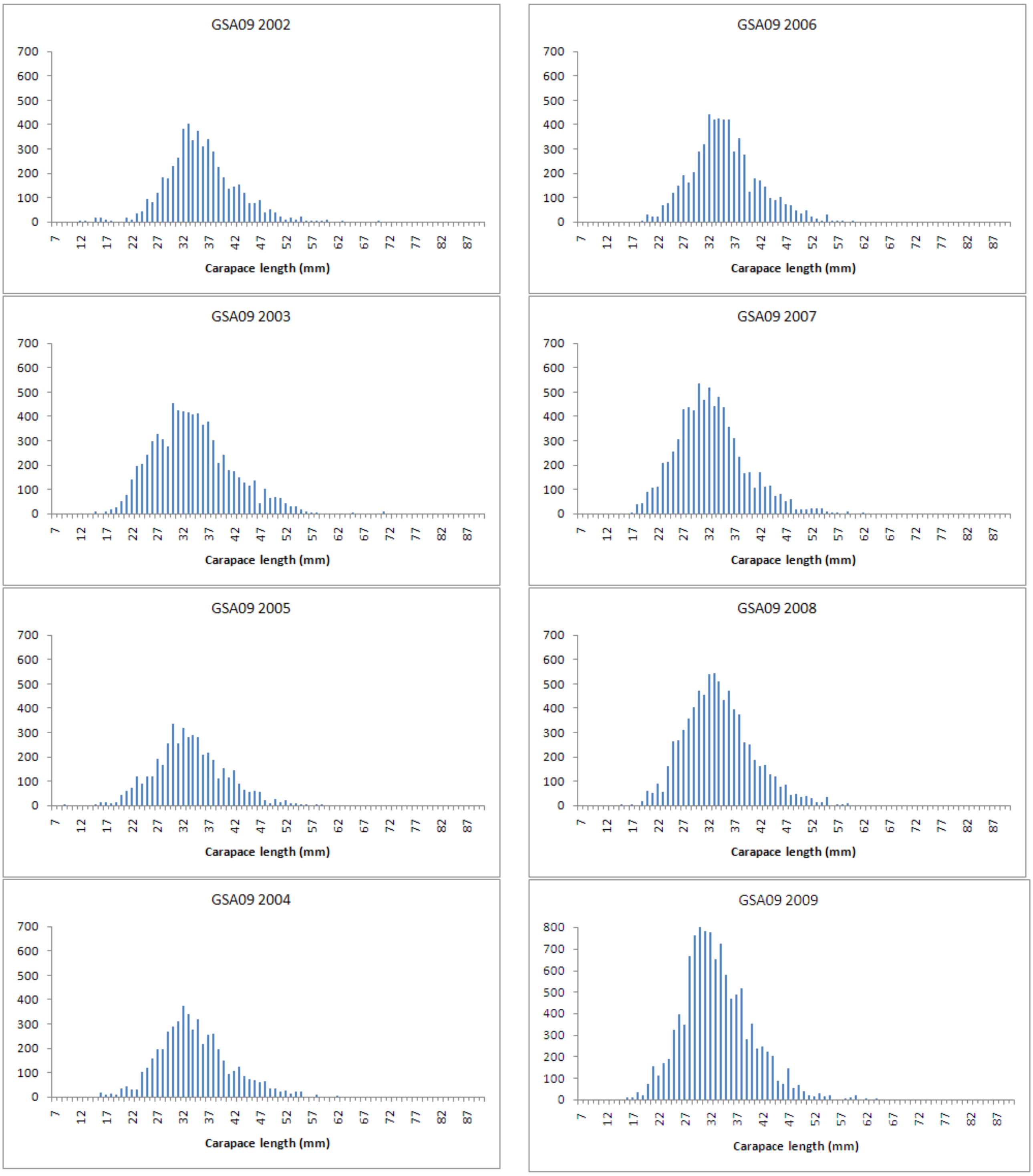


Fig. 5.62.3.1.4.2 Stratified abundance indices by size, 2002-2009.

An increasing trend was observed in MEDITS survey index (n km^{-2}) at age 3 (age group 2^{+}) which is the first age group completely recruited by the gear (Fig. 5.62.3.1.4.3).

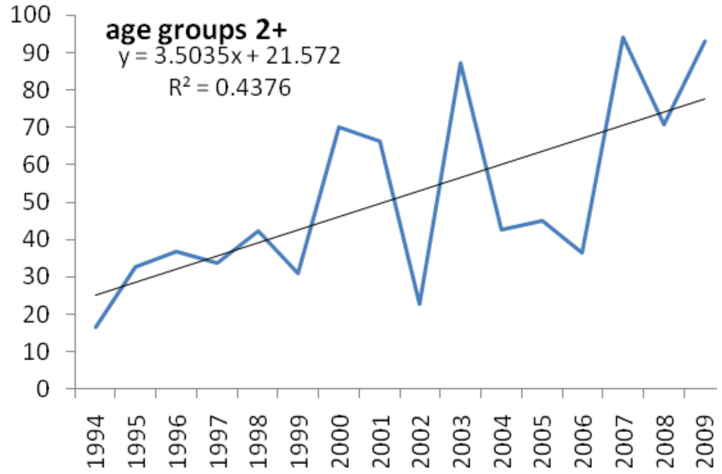


Fig. 5.62.3.1.4.3 MEDITS abundance indices of age groups 2+ (data pooled) of *N. norvegicus*.

5.62.3.2. GRUND

5.62.3.2.1. Methods

The national GRUND trawl survey (Relini, 1998) is regularly carried out along the Italian coasts in addition to MEDITS. It has been carried out since 1985, with some years lacking (1988, 1989 and 1999). Sampling is random stratified, except in the period 1990-93 where a different sampling design, based on transects, was applied. Locations of stations were selected randomly within each stratum in the period 1985-87, while since 1996, the same stations were sampled every year. Therefore from 1994 two trawl surveys are regularly carried out in Italy each year: MEDITS, in spring, and GRUND, in autumn. The two surveys provide integrate pictures on different seasons, allowing to monitor the most important biological events (recruitment, spawning) for the majority of the demersal species.

5.62.3.2.2. Geographical distribution patterns

Norway lobster is distributed in the whole GSA with the highest abundance in the south Ligurian Sea and northern Tyrrhenian Sea.

5.62.3.2.3. Trends in abundance and biomass

Fig. 5.62.3.2.3.1 shows the density and biomass indices of Norway lobster obtained from 1994 to 2008. The GRUND data series show a fluctuating trend and quite stable trend till 2006, while in 2008 values considerably lower than those of the previous years were recorded.

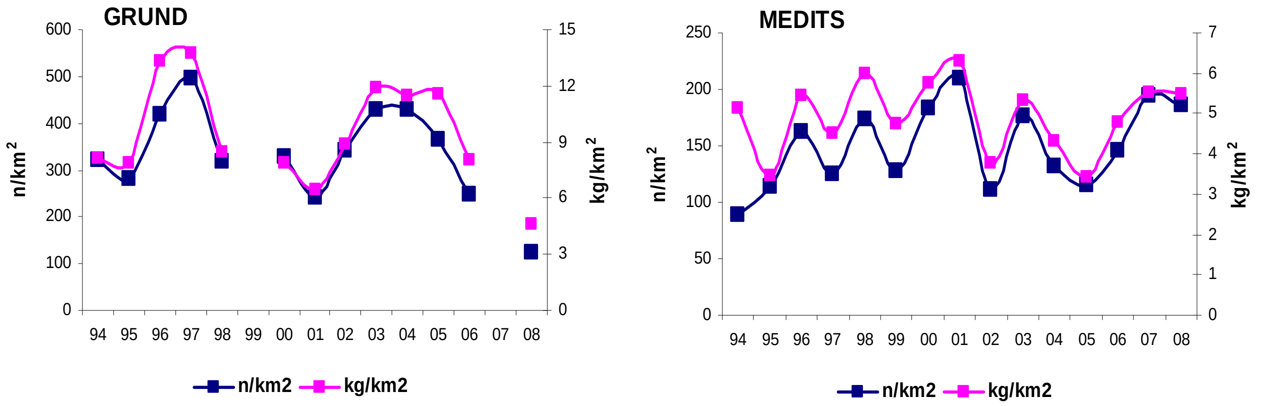


Fig. 5.62.3.2.3.1 Density and abundance indices of *N. norvegicus* according to the GRUND (left) and MEDITS (right) surveys.

5.62.3.2.4. Trends in abundance by length or age

Not presented to SGMED-10-02.

5.62.3.2.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.62.3.2.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.62.4. Assessment of historic stock parameters

Due to its importance as demersal resource, *N. norvegicus* has been object of several assessments in the GSA 09 (Ardizzone *et al*., 1998; Abella & Righini, 1995; 1998; Abella *et al*., 1999; 2002; 2007; Biagi *et al*., 1990a; 1990b; 1990c; De Ranieri 1999; Mori *et al*., 1993; 1998; Sartor *et al*., 2003, Sbrana *et al*., 2003). These results are published and have been regularly updated in the GFCM SAC. The assessments performed with different approaches in different periods or in different subareas of the GSA 09 showed divergent results as *Nephrops* grounds within GSA 09 are not exploited with the same rate. It is likely that the current status (abundance and demographic structure) may depend mainly on the fishing pressure exerted in the different sub areas of the GSA. This fact does not exclude the possibility of drifting of eggs and larvae from one ground to others contributing to recruitments in grounds different from the parental ones.

The Norway lobster in the GSA 09 seems to be fully or in some cases underexploited, as shown by the results of the analytical models (reference points as F_{max}, $F_{0.1}$ and SSB_{curr}/SSB_0). The production models based on Z provided total mortality estimates for the whole GSA 09 greater than the mortality corresponding to the maximum biological production (Z_{MBP}).

A clear growth overfishing is not observed, considering that the smaller individuals, 0+ and 1+ age classes, even though present in the fishing grounds, show a limited vulnerability to the fishing gear. The values of the SSB/SSB_0 ratio are between 0.33 and 0.45.

Two new assessments were produced by SGMED-09-02 in 2009 and are presented here again.

5.62.4.1. Method 1: SURBA

5.62.4.1.1. Justification

The relatively long time series of data available from the GRUND and MEDITS surveys provided the most important data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used both on MEDITS (1994-2007) and GRUND (1994-2004) data of the Norway lobster of GSA 09.

5.62.4.1.2. Input parameters

The following set of parameters was adopted:

Tab. 5.62.4.1.2.1 Input parameters.

Growth parameters (Von Bertalanffy)
$L\infty$ = 74 mm, carapace length
K = 0.17
to = 0
L*W
a = 0.0005
b = 3.04
Natural mortality
M = 0.4
Catchability (q)
q = 1 for all the age classes
Length at maturity (L50)
L50 = 29 mm

Tab. 5.62.4.1.2.2 Input parameters used for the SURBA model.

Abundance indices						Mean weight					
	Age						Age				
Year	3	4	5	6	7 plus	Year	3	4	5	6	7 plus
1994	60.946	63.556	30.673	12.25	6.964	1994	50.8	72.5	95.2	117.8	139.5
1995	80.366	72.157	30.413	10.785	8.456	1995	50.8	72.5	95.2	117.8	139.5
1996	144.074	117.405	27.992	4.658	2.276	1996	50.8	72.5	95.2	117.8	139.5
1997	97.535	78.183	32.36	13.149	11.054	1997	50.8	72.5	95.2	117.8	139.5
1998	138.817	107.463	49.734	18.362	10.939	1998	50.8	72.5	95.2	117.8	139.5
1999	97.647	84.989	32.917	12.558	10.991	1999	50.8	72.5	95.2	117.8	139.5
2000	143.239	103.062	37.82	17.306	11.701	2000	50.8	72.5	95.2	117.8	139.5
2001	193.001	118.264	42.596	14.213	9.258	2001	50.8	72.5	95.2	117.8	139.5
2002	89.481	75.401	29.724	11.083	5.916	2002	50.8	72.5	95.2	117.8	139.5
2003	133.345	87.239	36.739	17.392	12.053	2003	50.8	72.5	95.2	117.8	139.5
2004	111.043	76.458	29.057	12.392	9.341	2004	50.8	72.5	95.2	117.8	139.5
2005	96.326	59.498	27.529	8.589	5.157	2005	50.8	72.5	95.2	117.8	139.5
2006	118.943	94.291	33.57	14.526	8.125	2006	50.8	72.5	95.2	117.8	139.5
2007	177.222	84.955	31.544	12.319	7.343	2007	50.8	72.5	95.2	117.8	139.5
2008	151.37	107.783	41.734	13.949	9.235	2008	50.8	72.5	95.2	117.8	139.5
2009	171.25	82.30	24.40	10.48	3.93	2009	50.8	72.5	95.2	117.8	139.5
Proportion of mature											
1994	1	1	1	1	1						
1995	1	1	1	1	1						
1996	1	1	1	1	1						
1997	1	1	1	1	1						
1998	1	1	1	1	1						
1999	1	1	1	1	1						
2000	1	1	1	1	1						
2001	1	1	1	1	1						
2002	1	1	1	1	1						
2003	1	1	1	1	1						
2004	1	1	1	1	1						
2005	1	1	1	1	1						
2006	1	1	1	1	1						
2007	1	1	1	1	1						
2008	1	1	1	1	1						
2009	1	1	1	1	1						

5.62.4.1.3. Results

Fitted year effect shows strong fluctuations from year to year with a high increases from 2007 to 2008, while the age effect shows a flat-topped selection pattern for stock mortality with an increase from age 3 to age 6. Fitted cohort effects are high in recent years.

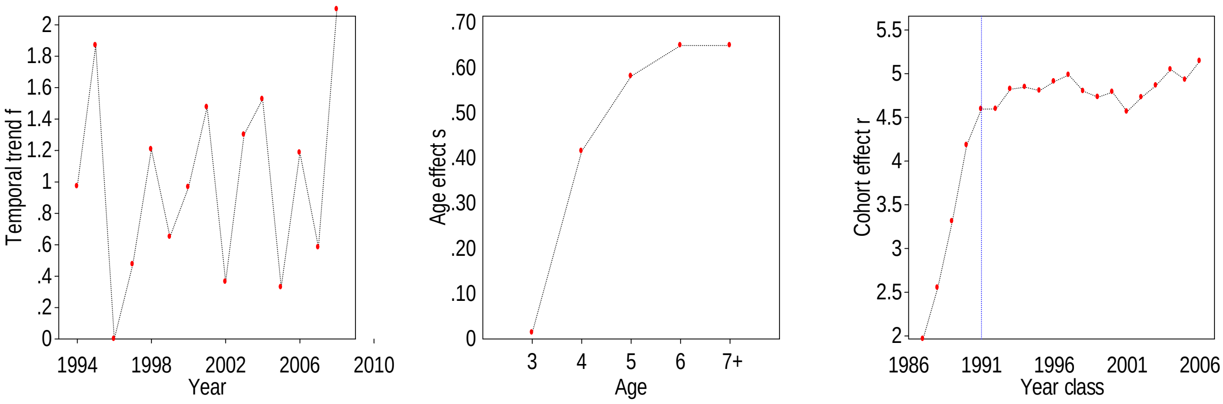


Fig. 5.62.4.1.3.1 MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.

SURBA fishing mortality ($F_{3\text{-}6}$) estimated with MEDITS fluctuated between 0.17 in 1996 and 0.62 in 2008. Relative spawning stock biomass (SSB) indices showed a fluctuating trend with two main peaks in 2001 and 2008 (Fig. 5.62.4.1.3.2).

Young of the year are poorly captured by the commercial fleet and during surveys. Relative indices for ages 2+, obtained from MEDITS survey indicated an increasing trend (Fig. 5.62.4.1.3.2).

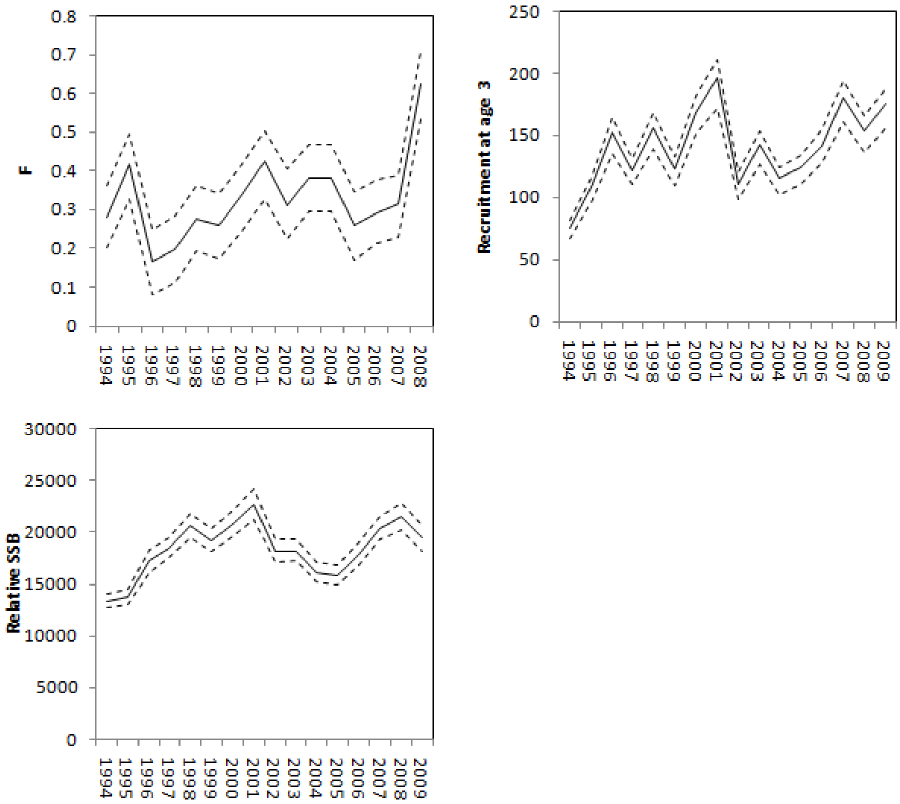


Fig. 5.62.4.1.3.2 MEDITS survey. SURBA estimates of mean $F_{3\text{-}6}$, SSB, and abundance at age 4

Model diagnostics are shown in the Fig. 5.62.4.1.3.3.

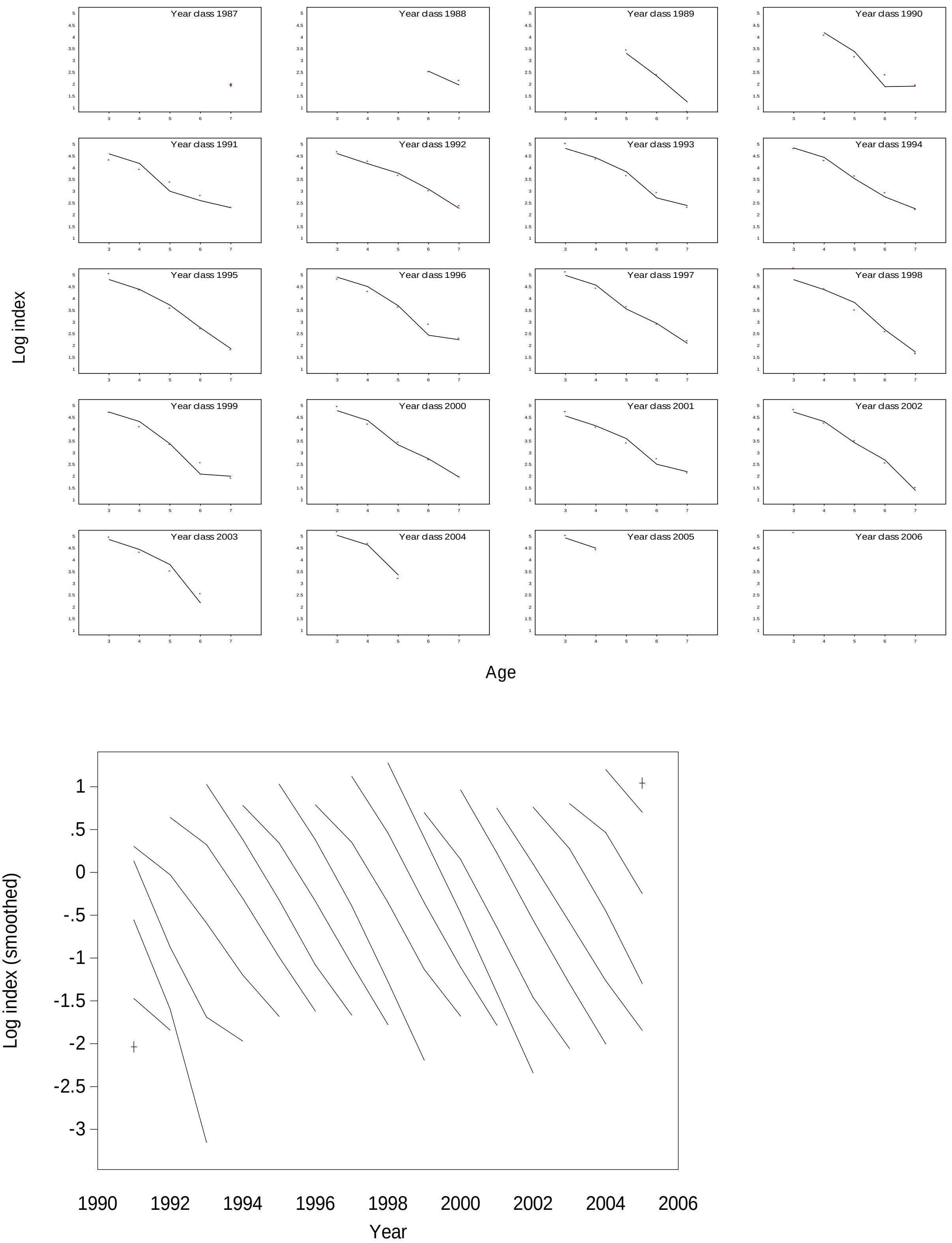


Fig. 5.62.4.1.3.3. Model diagnostic for Surba model in the GSA 09. a) Comparison between observed (points) and fitted (lines) of MEDITS survey abundance indices, for each year. b) Log survey abundance indices by cohort. Each line represents the fitted log index abundance of a particular cohort throughout its life.

5.62.4.2. Method 2: LCA on DCR data

5.62.4.2.1. Justification

Assessment was performed using an LCA (VIT software, Lleonart and Salat 1997) on an annual pseudocohort (2006-2008). Landings from 2009 were not submitted by the Italian authorities. Thus, this assessment has not been updated with 2009 data due to the lack of numbers-at-length or numbers-at-age landing data for 2009 in the dataset available during SGMED-10-02.

5.62.4.2.2. Input parameters

Data coming from DCR provided at SGMED-09-02 contained, for GSA 09, information on landings and the respective size/age structure for 2006-2008. The short data time series did not allow the application of VPA.

LCA was performed using VIT software on data of the years 2006, 2007, 2008. Tab. 5.62.4.2.2.1 shows the input data. The used parameters were the same of the SURBA analysis, including the M-vector and the maturity ogive.

Tab. 5.62.4.2.2.1. Input data for LCA of the Norway lobster in GSA 09.

Carapace Length (mm)	2006	2007	2008
18	0.0	16.0	63.9
20	45.3	160.7	103.2
22	99.3	221.2	159.9
24	203.2	363.4	260.8
26	388.2	384.0	473.2
28	790.4	401.4	572.2
30	1139.5	439.4	558.0
32	1055.9	581.5	603.3
34	650.3	543.6	587.2
36	444.0	490.6	622.7
38	279.5	331.6	423.3
40	252.8	187.5	357.8
42	177.3	178.5	192.3
44	173.5	167.7	271.7
46	120.5	253.8	147.1
48	82.3	269.7	66.2
50	249.3	175.9	89.5
52	34.4	213.8	148.8
54	14.8	151.6	70.5
56	18.5	10.1	14.3
58	16.4	4.2	19.7
60	12.2	5.0	8.8
62	0.0	2.9	1.9
64	0.0	0.4	0.5

5.62.4.2.3. Results

The general results of LCA (Fig. 5.62.4.2.3.1) show mean values of F (3-6) ranging from 0.30 to 0.36, very similar to those estimated with SURBA.

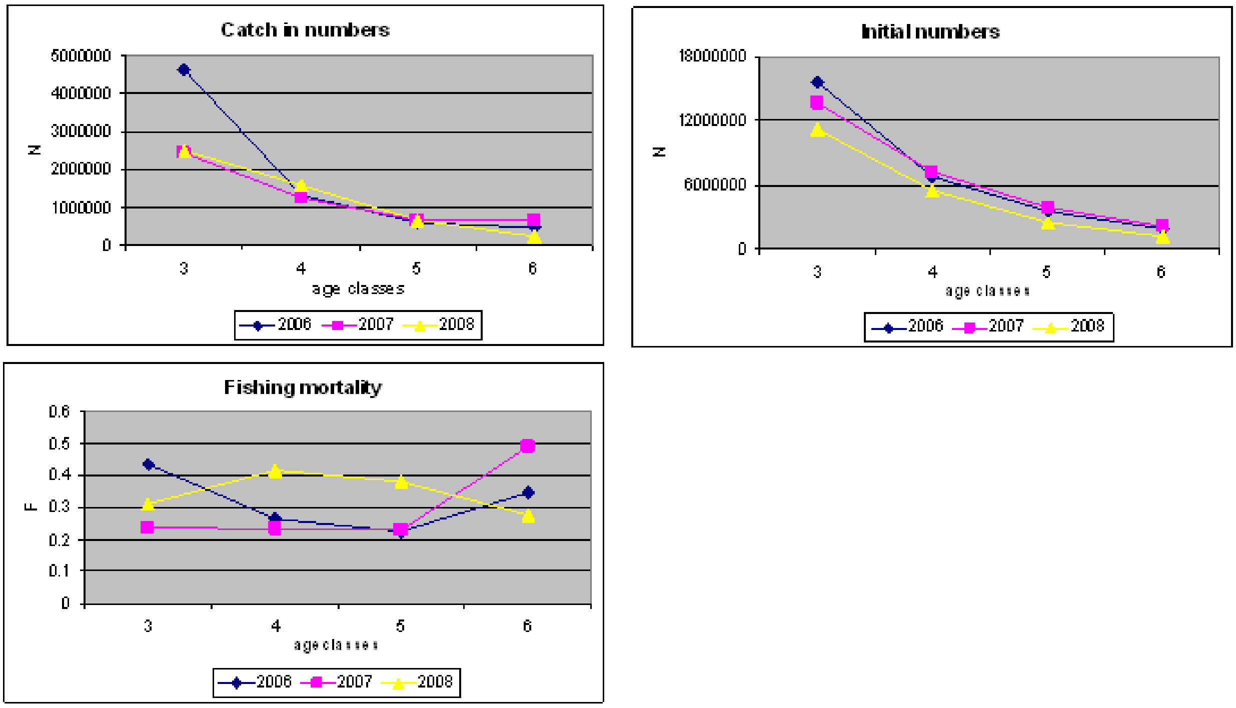


Fig. 5.62.4.2.3.1. LCA outputs: catch numbers, numbers-at-age and fishing mortality at age of *N. norvegicus* in GSA 09.

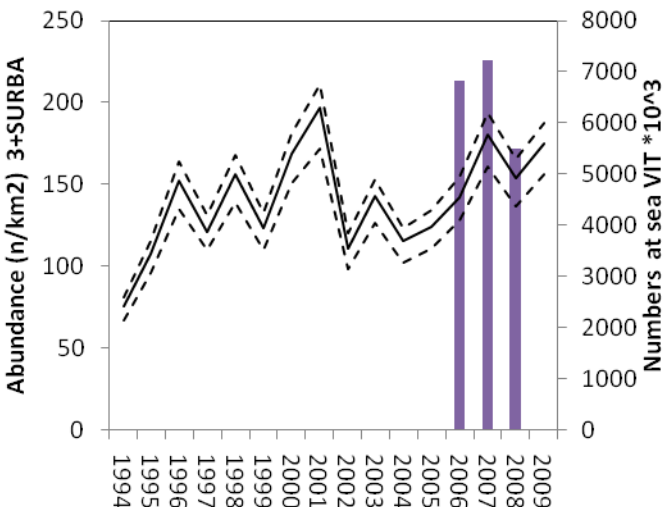


Fig. 5.62.5.2.3.2. Comparison between SURBA estimates of abundance-at-age 3 and numbers at sea for age 3 estimated from landing data for 2006-2008.

5.62.5. Long term prediction

5.62.5.1. Justification

Equilibrium YPR reference points for the stock estimated through the Yield software (Hoggarth *et al*., 2006) which assumesrecruitment fluctuating randomly around a constant value and 20% uncertainty in input parameters. Further YPR analyses were conducted based on the VIT (pseudocohort) results.

5.62.5.2. Input parameters

Parameters used were the same imputed for SURBA and LCA analyses.

5.62.5.3. Results

Yield software quantified uncertainty by repeatedly selecting a set of biological and fishery parameters by sampling from the probability distributions for uncertain parameters set by the user, and then calculating the quantities of interest. In this sampling, it is assumed that each of the uncertain parameters are independently distributed, even though for some biological parameters, this assumption is almost certainly incorrect (Hoggarth *et al*., 2006). F_{max} and $F_{0.1}$ were assumed respectively as limiting and target reference points. Their probability distributions showed a considerable variation (Fig. 5.62.5.3.1). The following median values were obtained: F_{max} = 0.36; $F_{0.1}$= 0.21. The maximum predicted values were respectively 0.59 (F_{max}) and 0.30 (F_{01}).

Considering that the estimated current F was around 0.3 with a SURBA estimates of RPs suggest that the *N. norvegicus* stock is currently overexploited.

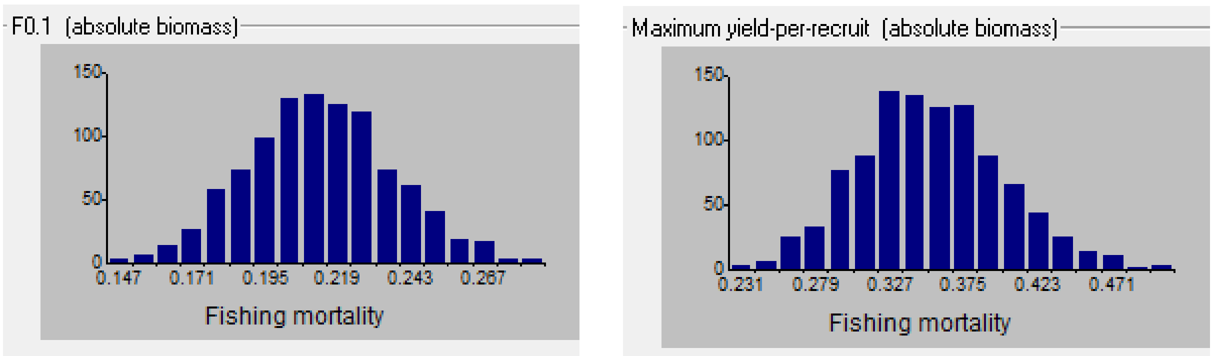


Fig. 5.62.5.3.1 Probability distribution of Norway lobster RPs in the GSA 09 obtained using the Yield software.

5.62.6. Data quality and availability

MEDITS survey data were available from 1994. A check of hauls allocation between GSA 09 and 10 needs to be done before calculation of indices from JRC MEDITS database. Landings from 2009 were not submitted by the Italian authorities while effort data seem not consistent with previous estimates for the GSA. Due to lack of numbers-at-age or numbers-at-length from the landings the update of the assessment in 2009 was therefore not carried out.

5.62.7. Scientific advice

5.62.7.1. Short term considerations

5.62.7.1.1. State of the spawning stock size

Relative spawning stock biomass (SSB) indices derived from MEDITS (1994-2009) and GRUND (1994-2006) showed fluctuations without a particular trend in the spawning stock biomass (SSB). However, both indices of abundance and biomass in 2009 represent the maximum values since 1994.

SGMED-10-02 cannot fully evaluate the state of the SSB due to a lack of precautionary management reference points.

5.62.7.1.2. State of recruitment

Recruitment (age groups 1+ and 2+) showed a significant increasing trend since 1994.

5.62.7.1.3. State of exploitation

SGMED-10-02 proposes the estimated $F_{0.1}$ =0.21 as limit management reference point for sustainable exploitation consistent with high long term yield.

Recent values of $F_{3\text{-}7}$ obtained on commercial data with LCA (VIT) and using SURBA indicate that the stock is currently overexploited. SGMED-10-02 recommends a reduction of fishing effort to be achieved by means of a multiannual management plan towards the proposed management reference point in order to avoid long term losses in yield. Such management plan should consider the mixed fisheries implications for the Nephrops fisheries. SGMED-10-02 recommends the resulting catches consistent with the effort reductions be determined.

5.63. Stock assessment of Norway lobster in GSA 10

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.63.1. Stock identification and biological features

5.63.1.1. Stock Identification

The stock of Norway lobster was assumed in the boundaries of the whole GSA 10, lacking specific information on stock identification. *N. norvegicus* is a sedentary long-living, slow growing lobster which inhabits burrows constructed in muddy substrates of the upper slope and its presence appears to be related with heterogeneity in the characteristics of the sediment as well as with variations in fishing effort (e.g. Maynou and Sardà, 1997). Abundance of Norway lobster is generally rather scant in the southern Tyrrhenian Sea and the areas with the highest concentration of biomass are found between 200 and 500 m depth. Patchiness in population structure characteristics has been also identified in the GSA 10.

It has been reported that in GSA 10 the mean length of this crustacean is slightly lower than in the Northern Tyrrhenian but higher (38 against 39) than in Sicily Strait (38 against 34). Total mortality has been found negatively correlated with the mean size obtained in different Mediterranean GSAs, although also environmental influences at geographical scale could play an important role (Abellò *et al.*, 2002). Indeed, differences in growth have been highlighted for *N. norvegicus* from different habitats in the same geographical area (Central Adriatic) (Froglia and Gramitto, 1988).

The overall sex ratio is about 0.5. The Norway lobster is a long-living crustacean with a life span of 16-18 years (SAMED, 2002) and larger individuals are males.

In the Central-Southern Tyrrhenian Sea the occurrence of mature females was observed in late spring-early summer with a spawning beginning mainly at the end of the summer (September, Carbonara *et al*., 2006) as reported by other authors for the western Mediterranean basin (Orsi Relini *et al*., 1998). Thus, a continuous recruitment pattern is shown and at 34-36 mm carapace length the Norway lobster is considered recruited to the grounds (SAMED, 2002).

In the central-southern Tyrrhenian Sea commercial catches of Norway lobster are taken on the same fishing grounds as pink shrimp and European hake but are less abundant than other crustaceans (AA.VV., 2000; EU project 97/0066 –Medland).

5.63.1.2. Growth

Estimates of the growth pattern of Norway lobster in the Tyrrhenian Sea were obtained in the Samed project (SAMED, 2002) according to the following procedure. L_{max} (predicted maximum length; procedure implemented in FiSAT) value to be used as guess estimate of L_∞ was computed for each sex. This value was then tuned with that obtained from the Powell and Wetherall approach, which gives also estimates of the Z/K ratio. According to literature (Mytilineou *et al*., 1998) estimate of the phi' indicator was obtained and thus preliminary guess values of K computed. Thus also a first value of Z was obtained. These parameters were finally calibrated through the Length Converted Catch Curve (LCCC) and the set giving the better determination coefficient was adopted: females CL_∞=60 mm; K=0.18; t_0= -0.5; males CL_∞=72 mm; K=0.17; t_0= -0.5.

In the DCR framework parameters were re-estimated following the same procedure and the following values were obtained: females CL_∞=58 mm; K=0.19; t_0= -0.2; males CL_∞=75 mm; K=0.15; t_0= -0.5.

Parameters of the length-weight relationship were a=0.668, b=3.027 for females and a=0.7329, b=2.991 for males (length in cm).

5.63.1.3. Maturity

Maturity and fecundity of Norway lobster have been studied in the GSA 10 using trawl-survey data (1994-2004) collected in a ten years period (20 surveys carried out in late spring and early summer) (Carbonara *et al.*, 2006). Results evidenced that maturity process is completed from late-spring summer through autumn and the smallest ovigerous female was 23.5 mm carapace length. Length at first maturity (Lm_{50}) was within 30.6-34.8 mm, depending on the year. These differences were probably due to the seasonal variations and diverse availability of the species to the gear. The lower value was similar to findings in other Mediterranean areas (29.9 mm-32.1 mm: e.g. Bianchini *et al.*, 1998; SAMED, 2002), while the upper size was higher and more close to the Alboran figure (36 mm; Orsi Relini *et al.*, 1998).

The proportion of mature females per length class (Tab. 5.63.1.3.1) from DCR data is similar to the estimates previously calculated for the area.

The relationship between carapace length and number of early eggs on the pleopods is fitted by the following non-linear equation: $F=0.0029*LC^{3,7221}$ (R^2=0.79) comparable with the findings of Froglia and Gramitto (1980).

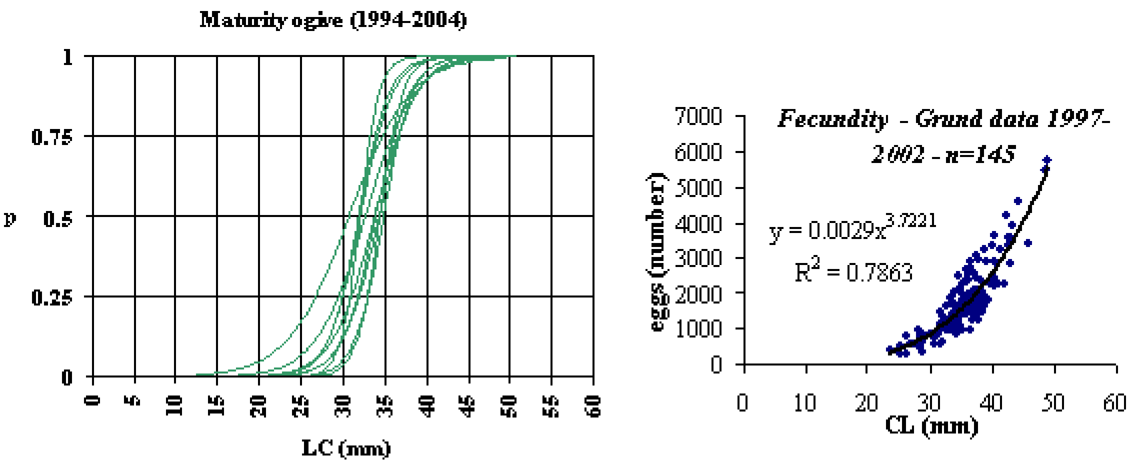


Fig. 5.63.1.3.1 The maturity ogives and relationship between fecundity and carapace length of females.

Tab. 5.63.1.3.1 Proportion of mature females for length class from DCR.

CL	Proportion of mature females
2.6	0.017
2.8	0.05
3	0.119
3.2	0.362
3.4	0.557
3.6	0.779
3.8	0.938
4	1

The sex ratio from DCR evidenced the prevalence of males in the different size classes.

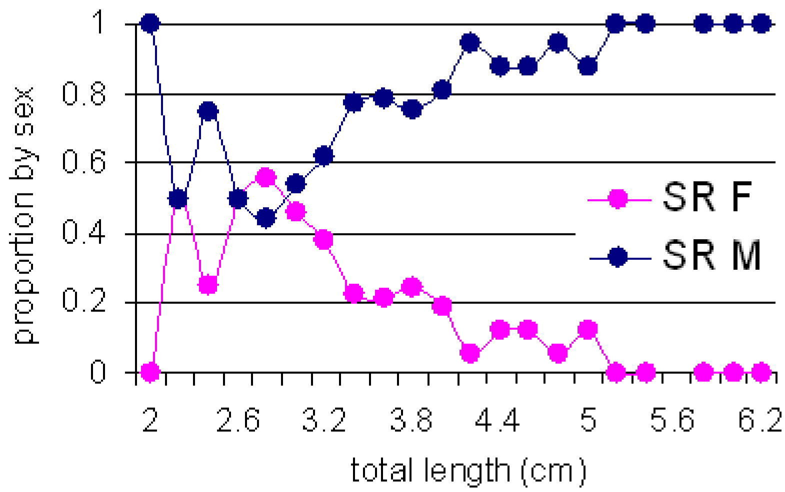


Fig. 5.63.1.3.2 Sex ratio over length (carapace length).

5.63.2. Fisheries

5.63.2.1. General description of fisheries

The Norway lobster is only targeted by trawlers on fishing grounds located offshore at 200 m depth, on the slope of the whole GSA. The Norway lobster occurs mainly with *M. merluccius*, *P. longirostris*, *P. blennoides*, depending on depth and area.

5.63.2.2. Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures, like the number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late 1980s. After 2000, in agreement with the European Common Fisheries Policy, a gradual decreasing of the fleet capacity is implemented. Along the northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990. Two closed areas were also established in 2004 along the mainland, in front of Sorrento peninsula (Napoli Gulf) and Amantea (Calabrian coasts), although these protected area mainly cover the distribution of coastal species. Other measures on which the management regulations are based regard technical measures (mesh size) and minimum landing sizes (EC reg. 1967/06). In the GSA 10, the fishing ban has not been mandatory and it has been adopted on a voluntary basis by the fleet.

5.63.2.3. Catches

5.63.2.3.1. Landings

Available landing data are from DCR regulations. Italian landings data for GSA 10 by fishing gears are listed in Tab. 5.63.2.3.1.1. Most part of the landings is from trawlers. No data for 2009 were provided by the Italian authorities.

Tab. 5.63.2.3.1.1. Annual landings (t) by fishing technique as provided through the official 2010 DCF data call, 2004-2008. No data for 2009 were provided by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
NEP	10	ITA	GNS	DEMSP				6	14	9	10	8	
NEP	10	ITA	GTR	DEMSP				1		0			
NEP	10	ITA	OTB	DEMSP				7		2	1	7	
NEP	10	ITA	OTB	DWSP						0	0	0	
NEP	10	ITA	OTB	MDDWSP				50	73	55	53	23	
NEP	10	ITA	SB-SV	DEMSP				0					
Sum								64	87	66	64	38	

5.63.2.3.2. Fishing effort

The trends in fishing effort by year and gear type is listed in Tab. 5.63.2.3.2.1. No 2009 data were provided by the Italian authorities.

Tab. 5.62.2.3.2.2 Trend in fishing effort (kW*days) for GSA 10 by fishing technique as reported through the official 2010 DCF data call, 2004-2008. No 2009 data were provided by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
10	ITA				VL0006				1347			
10	ITA				VL0612		84318	65385	32480	27509	24608	
10	ITA				VL1218		13612	27229	5986	18865	7513	
10	ITA	DRB	MOL		VL1218		10149	14848	23073	34394	21067	
10	ITA	FPO	DEMSP		VL0006				5938			
10	ITA	FPO	DEMSP		VL0612			14239				
10	ITA	GND	SPF		VL0006					1521	1437	
10	ITA	GND	SPF		VL0612			4316	8070		15882	
10	ITA	GND	SPF		VL1218		1895	3429			8303	
10	ITA	GNS	DEMSP		VL0006				221	9122	6623	
10	ITA	GNS	DEMSP		VL0612		45875	229661	74360	139622	124448	
10	ITA	GNS	DEMSP		VL1218						18180	
10	ITA	GTR	DEMSP		VL0006				30332	16894	13248	
10	ITA	GTR	DEMSP		VL0612		86781	82711	191382	140832	172542	
10	ITA	GTR	DEMSP		VL1218		12514	21108	28430	16110	17755	
10	ITA	LHP-LHM	CEP		VL0006				2369	3463	1018	
10	ITA	LHP-LHM	CEP		VL0612		1239	2450	4458	15003		
10	ITA	LHP-LHM	FINF		VL1218		716	1013				
10	ITA	LLD	LPF		VL0006						1968	
10	ITA	LLD	LPF		VL0612						2138	
10	ITA	LLD	LPF		VL1218		4627		10673	10266	14174	
10	ITA	LLS	DEMF		VL0006				11628	3467	2996	
10	ITA	LLS	DEMF		VL0612		104125	101629	61456	56957	26693	
10	ITA	LLS	DEMF		VL1218		13376	27517	61348	52670	32330	
10	ITA	OTB	DEMSP		VL0612		16454					
10	ITA	OTB	DEMSP		VL1218		44743		102448	127832	98014	
10	ITA	OTB	DEMSP		VL1824		90104		224283	204068	242063	
10	ITA	OTB	DWSP		VL1824						2388	
10	ITA	OTB	MDDWSP		VL1218		130612	247796	142430	169560	83026	
10	ITA	OTB	MDDWSP		VL1824		97221	239878	71963	86844	55526	
10	ITA	PS	LPF		VL0612					5291		
10	ITA	PS	LPF		VL1218					4926		
10	ITA	PS	SPF		VL0006				7337			
10	ITA	PS	SPF		VL0612		4653	27986				
10	ITA	PS	SPF		VL1218		49995	54113	68805	73452	20179	
10	ITA	SB-SV	DEMSP		VL0006				0			
10	ITA	SB-SV	DEMSP		VL0612		12786					
10	ITA	SB-SV	DEMSP		VL1218						8756	

5.63.3. Scientific surveys

5.63.3.1. Medits

5.63.3.1.1. Methods

According to the MEDITS protocol (Bertrand *et al*., 2002), trawl surveys were carried out yearly (May-July), applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini

(1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometre, using the swept area method.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls was reported per depth stratum (Tab. 5.63.3.1.1.1).

Tab. 5.63.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA10_010-050	9	10	10	10	10	10	10	10	9	9	9	9	9	9	9	9
GSA10_050-100	12	12	12	12	12	12	12	12	10	10	10	10	10	10	10	10
GSA10_100-200	20	20	20	20	20	20	20	20	17	17	17	17	17	17	17	17
GSA10_200-500	26	27	26	26	27	26	26	28	22	22	22	22	22	22	22	22
GSA10_500-800	31	30	31	31	31	30	31	29	26	27	26	26	26	26	26	26

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.63.3.1.2. Geographical distribution patterns

No analyses based on Medits data were presented.

5.63.3.1.3. Trends in abundance and biomass

The re-estimated abundance and biomass indices are shown in Figure 5.63.3.1.3.1. No trends are evident.

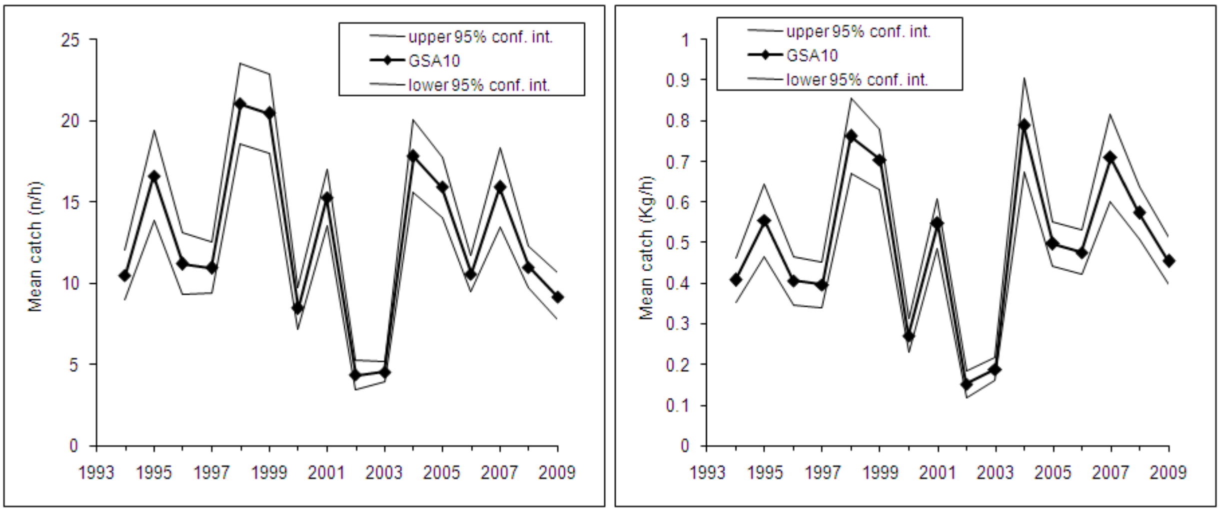


Fig. 5.63.3.1.3.1 Trends in survey abundance and biomass indices (Medits) of Norway lobster in GSA 10.

5.63.3.1.4. Trends in abundance by length or age

The following Fig. 5.63.3.1.4.1 and 2 display the stratified abundance indices of GSA 10 in 1994-2001 and 2002-2009.

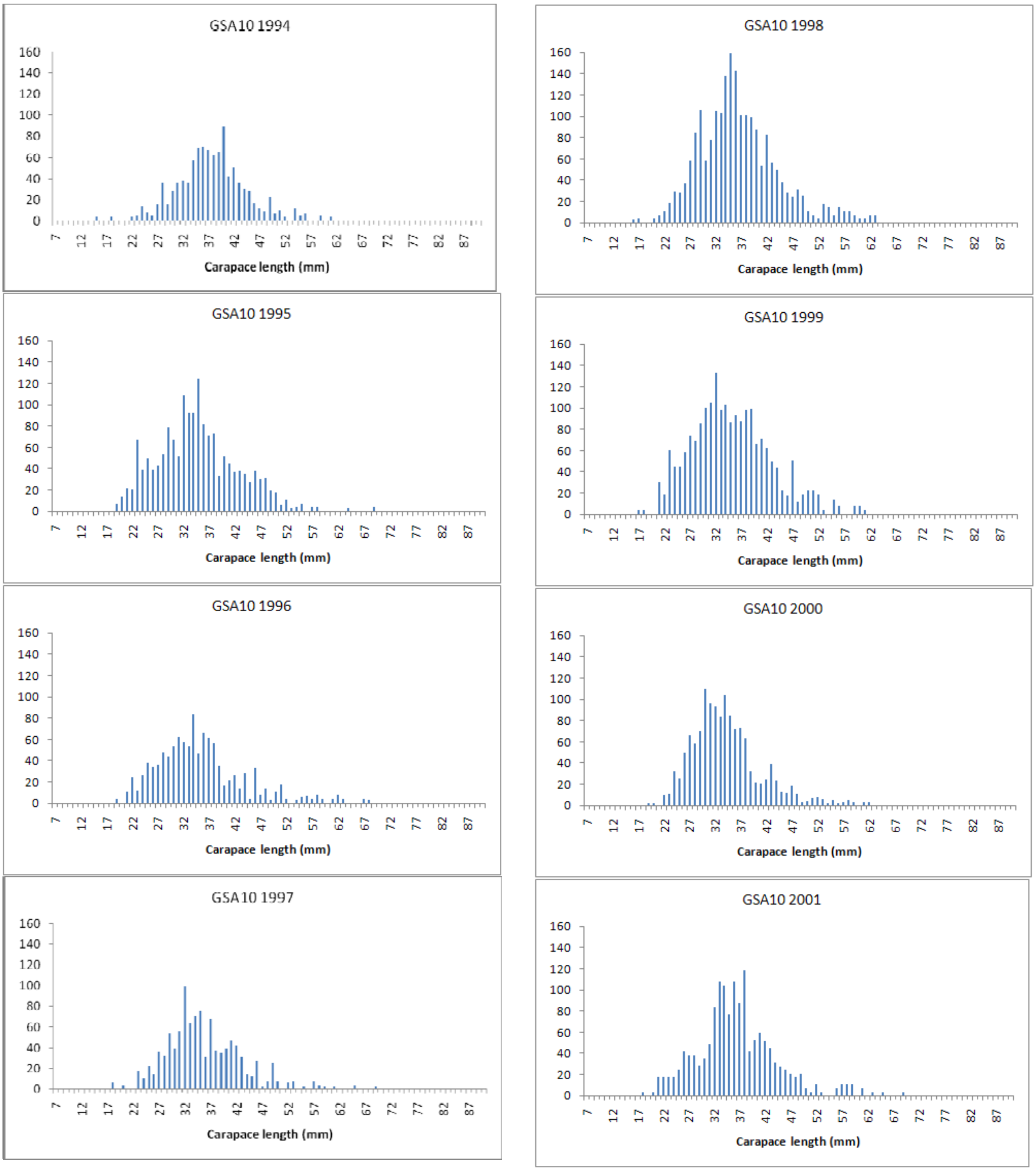


Fig. 5.63.3.1.4.1 Stratified abundance indices by size, 1994-2001.

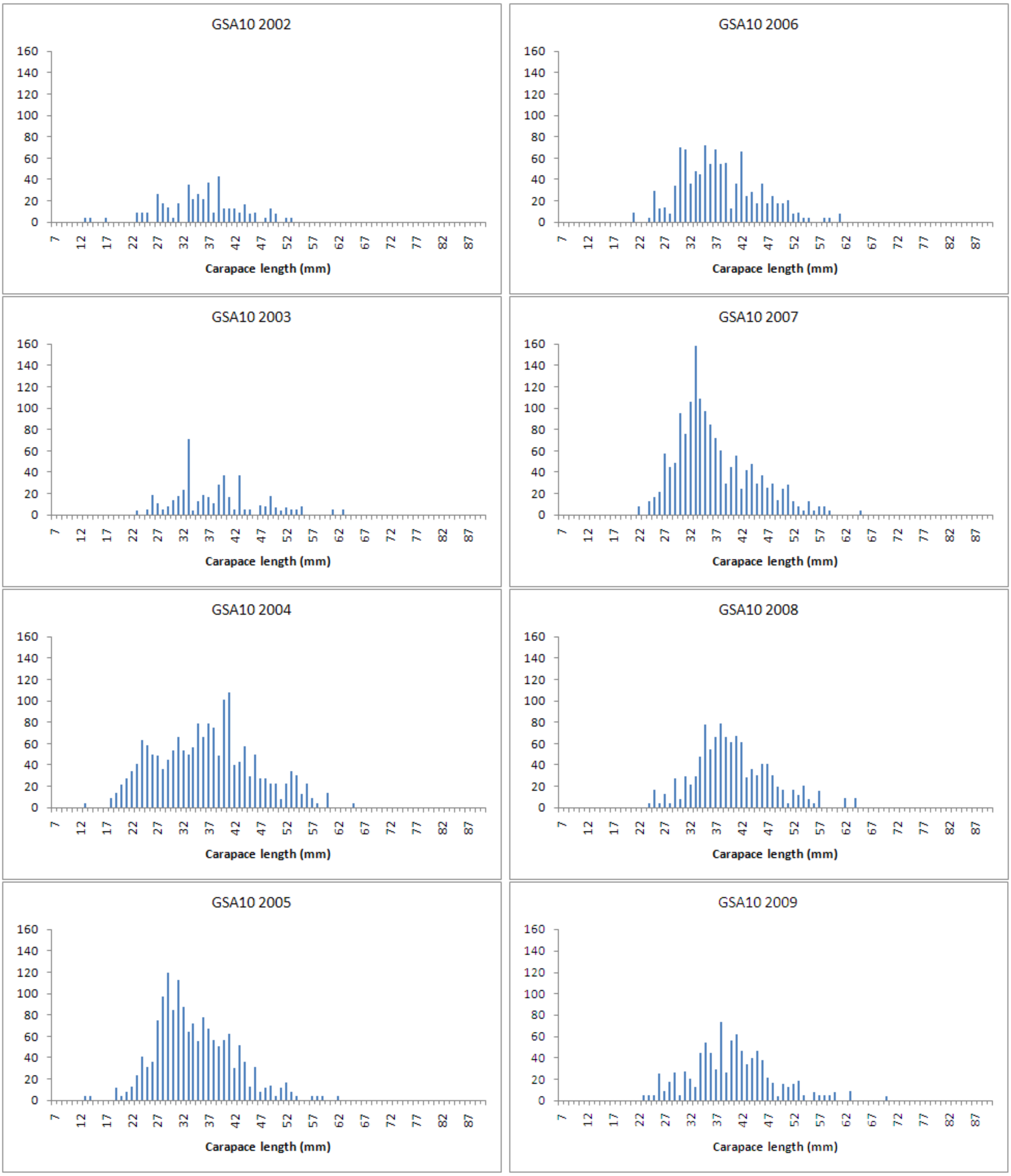


Fig. 5.63.3.1.4.2. Stratified abundance indices by size, 2002-2009.

5.63.3.2. GRUND

5.63.3.2.1. Methods

Since 2003 Grund surveys (Relini, 2000) was conducted using the same sampler (vessel and gear) in the whole GSA. Sampling scheme, stratification and protocols were similar as in Medits. All the abundance and biomass data were standardised to the square kilometre, using the swept area method.

5.63.3.2.2. Geographical distribution patterns

The geographical distribution pattern of the Norway lobster has been studied in the area using trawl-survey data (Grund and Medits), length frequency distribution analyses via modal component separation techniques and geostatistical methods. Nurseries were localized with a higher level of probability offshore the Garigliano river in the northernmost part of the GSA and offshore Capo Suvero, on the southern part of the area. These areas were also persistent along the time.

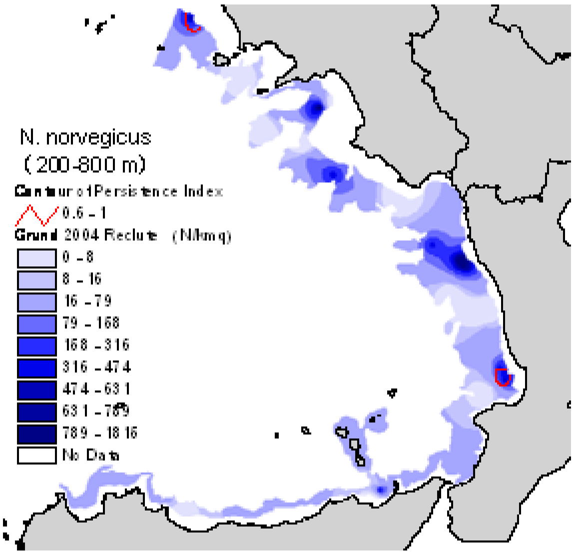


Fig. 5.63.3.2.2.1 Map of nursery area of Norway lobster.

5.63.3.2.3. Trends in abundance and biomass

Trends derived from the GRUND surveys are shown in Fig. 5.63.3.2.3.1. Abundance and biomass indices show an increasing trend up to 2005 and a decreasing in 2006, as well as recruitment indices. In 1999 the survey was not performed.

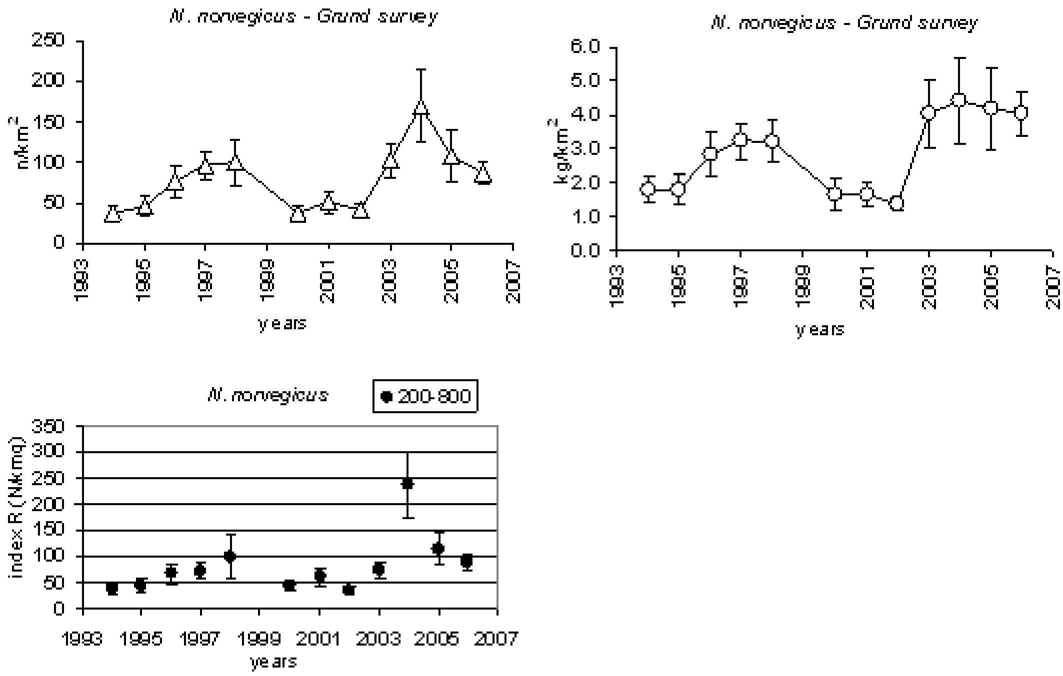


Fig. 5.63.3.2.3.1. Abundance and biomass indices of the Norway lobster in GSA 10 (bars indicate standard deviations) derived from Grund surveys. Recruitment indices (N/km^2) computed in the total depth range with standard deviation is also reported.

5.63.3.2.4. Trends in abundance by length or age

Grund time series of length structures from 1994 to 2006 (Fig. 5.63.3.2.4.1) did not show any trend.

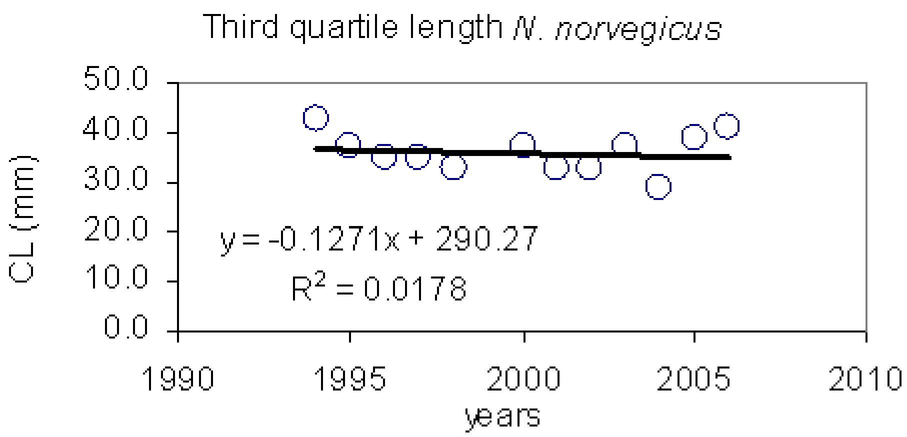


Fig. 5.63.3.2.4.1 III Quantile derived from the GRUND length structures in 1994-2006.

5.63.3.2.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.63.3.2.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.63.4. Assessment of historic stock parameters

No analytical assessment of historic stock parameters was conducted.

5.63.5. Long term prediction

5.63.5.1. Justification

No forecast analyses were conducted.

5.63.5.2. Input parameters

No forecast analyses were conducted.

5.63.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a short term prediction of catch and stock biomass for Norway lobster in GSA 10.

5.63.6. Scientific advice

5.63.6.1. Short term considerations

5.63.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.63.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of recruitment in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.63.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of exploitation in relation to proposed precautionary level given the preliminary state of the data and analyses.

5.64. Stock assessment of Norway lobster in GSA 11

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.64.1. Stock identification and biological features

5.64.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.64.1.2. Growth

No information was documented during SGMED-10-02.

5.64.1.3. Maturity

No information was documented during SGMED-10-02.

5.64.2. Fisheries

5.64.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.64.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.64.2.3. Catches

5.64.2.3.1. Landings

Tab. 5.64.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. The landings were mainly taken by demersal otter trawls.

Tab. 5.64.2.3.1.1 Annual landings (t) by fishing technique in GSA 11 as reported through the official DCF 2010 data call. No 2009 data were submitted by Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
NEP	11	ITA	GNS	DEMSP								0	
NEP	11	ITA	GTR	DEMSP								0	
NEP	11	ITA	OTB	DEMSP				3				3	
NEP	11	ITA	OTB	DWSP								5	
NEP	11	ITA	OTB	MDDWSP				58	29	48	61	47	
Sum								61	29	48	61	55	

5.64.2.3.2. Discards

According to information available to the SGMED-10-02 no catches of Norway lobster were discarded by the Italian fleet.

5.64.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.64.2.3.3.1.

Tab. 5.64.2.3.3.1 Trends in annual fishing effort (kW*days) by fishing technique deployed in GSA 11 as reported through the official 2010 DCF data call, 2004-2008. No 2009 data were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
11	ITA	FPO	DEMSP		VL0006					8227	1107	
11	ITA	FPO	DEMSP		VL0612				13379	69823	43856	
11	ITA	FPO	DEMSP		VL1218					16165	4731	
11	ITA	FYK	DEMSP		VL0006						0	
11	ITA	GNS	DEMSP		VL0006				0	3950	2439	
11	ITA	GNS	DEMSP		VL0612		22701	54787	5413	44336	35469	
11	ITA	GNS	DEMSP		VL1218		5248	39173	9568	7130	19593	
11	ITA	GTR	DEMSP		VL0006				5465	5988	4328	
11	ITA	GTR	DEMSP		VL0612			38115	82656	176487	116844	
11	ITA	GTR	DEMSP		VL1218		1814	54332	19069	75188	64023	
11	ITA	LHP-LHM	CEP		VL0006					4305	1131	
11	ITA	LHP-LHM	CEP		VL0612		3065		2611	9764	3353	
11	ITA	LHP-LHM	CEP		VL1218					12237	4371	
11	ITA	LHP-LHM	FINF		VL0612						3480	
11	ITA	LLD	LPF		VL1218			6694				
11	ITA	LLD	LPF		VL2440					1975		
11	ITA	LLS	DEMF		VL0006				228	2263	0	
11	ITA	LLS	DEMF		VL0612		50046	61709	4253	76836	29234	
11	ITA	LLS	DEMF		VL1218		3499	34499	20040	43290	25525	
11	ITA	LLS	DEMF		VL2440					13170		
11	ITA	OTB	DEMSP		VL1218		75568	77835	108842		95470	
11	ITA	OTB	DEMSP		VL1824						66067	
11	ITA	OTB	DEMSP		VL2440						22082	
11	ITA	OTB	MDDWSP		VL1218					152444	8561	
11	ITA	OTB	MDDWSP		VL1824		115969	188926	141391	195889	35045	
11	ITA	OTB	MDDWSP		VL2440		213246	234872	190232	187054	126564	
11	ITA	PS	SPF		VL1218		4109					

5.64.3. Scientific surveys

5.64.3.1. Medits

5.64.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 11 the following number of hauls was reported per depth stratum (s. Tab. 5.64.3.1.1.1).

Tab. 5.64.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18
GSA11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20
GSA11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24
GSA11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19
GSA11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.64.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.64.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the Norway lobster in GSA 11 was derived from the international survey Medits. Figure 5.64.3.1.3.1 displays the estimated trend in Norway lobster abundance and biomass in GSA 11. The indices do not reveal a particular trend but stock size is indicated to be high during 2006-2009.

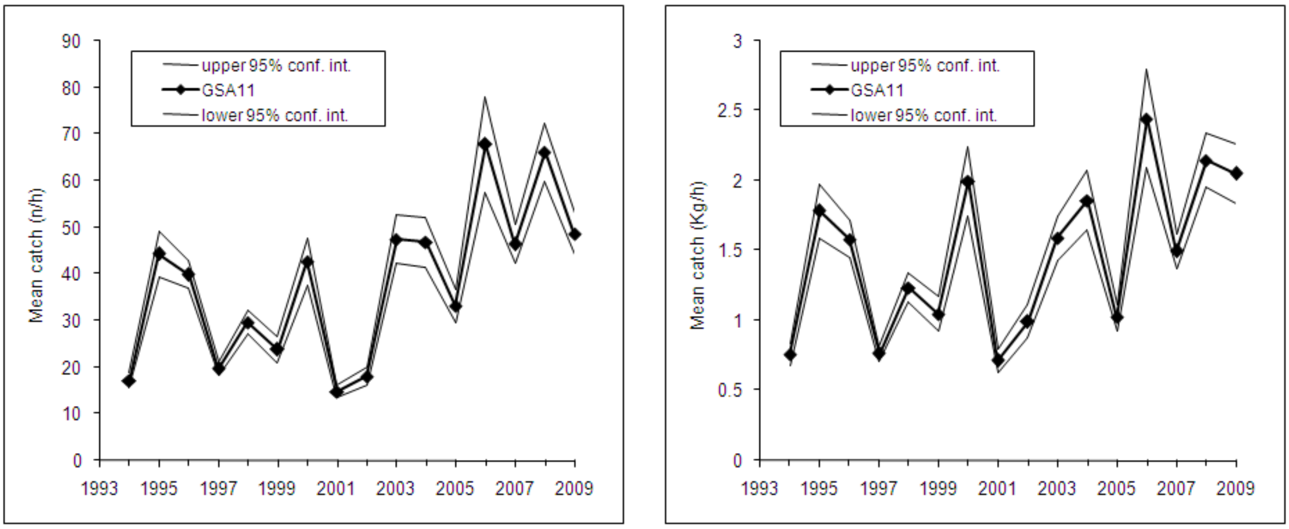


Fig. 5.64.3.1.3.1 Abundance and biomass indices of Norway lobster in GSA 11.

5.64.3.1.4. Trends in abundance by length or age

The following Fig. 5.64.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2009.

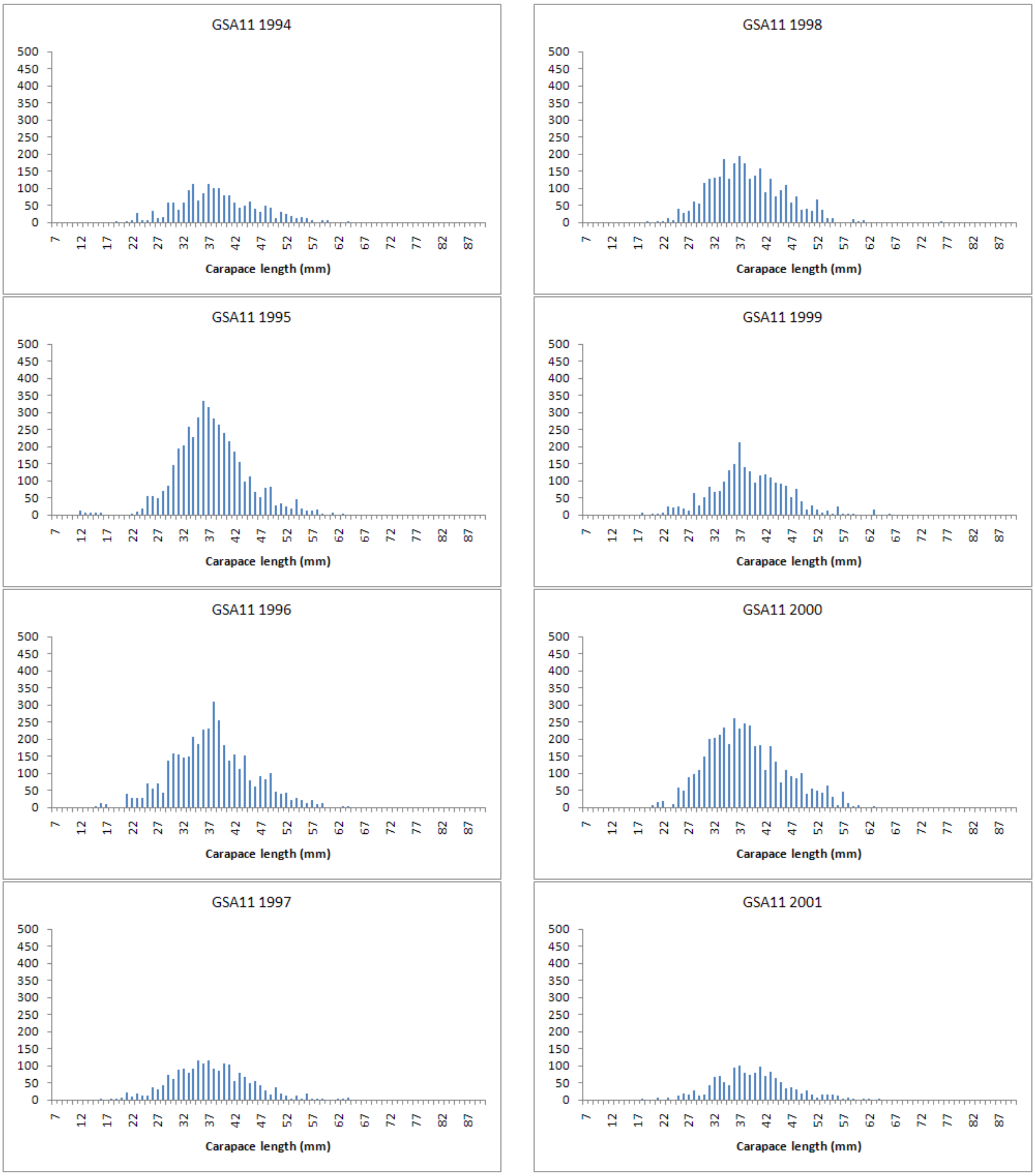


Fig. 5.64.3.1.4.1 Stratified abundance indices by size, 1994-2001.

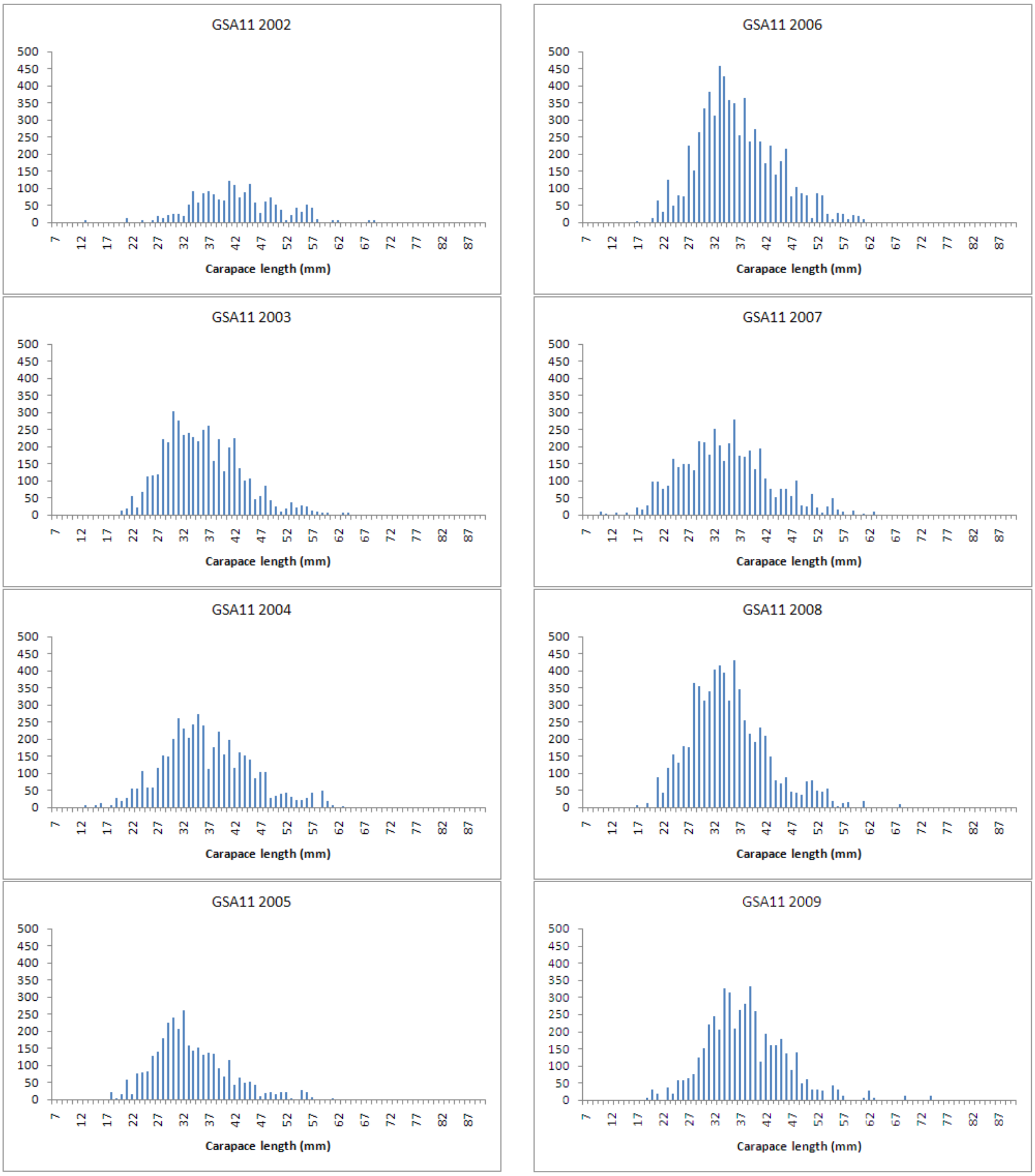


Fig. 5.64.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.64.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.64.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.64.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.64.5. Long term prediction

5.64.5.1. Justification

No forecast analyses were conducted.

5.64.5.2. Input parameters

No forecast analyses were conducted.

5.64.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for Norway lobster in GSA 11.

5.64.6. Scientific advice

5.64.6.1. Short term considerations

5.64.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses. Survey indices do not reveal a particular trend but stock size is indicated to be high during 2006-2009.

5.64.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.64.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation given the preliminary state of the data and analyses.

5.65. Stock assessment of Norway lobster in GSA 16

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.65.1. Stock identification and biological features

5.65.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.65.1.2. Growth

No information was documented during SGMED-10-02.

5.65.1.3. Maturity

No information was documented during SGMED-10-02.

5.65.2. Fisheries

5.65.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.65.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.65.2.3. Catches

5.65.2.3.1. Landings

Tab. 5.65.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. The landings were mainly taken by demersal otter trawls.

Tab. 5.65.2.3.1.1 Annual landings (t) by fishing technique in GSA 16 as provided through the official 2010 DCF data call. No data for 2009 were submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
NEP	16	ITA	OTB	DEMSP				14	7	5		408	
NEP	16	ITA	OTB	DWSP								50	
NEP	16	ITA	OTB	MDDWSP				414	483	669	797	215	
Sum								428	490	674	797	673	

5.65.2.3.2. Discards

According to information available to the SGMED-10-02 no catches of Norway lobster were discarded by the Italian fleet.

5.65.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.65.2.3.3.1.

Tab. 5.65.2.3.3.1 Trends in annual fishing effort (kW*days) by fishing technique deployed in GSA 16 as provided through the official 2010 DCF data call, 2004-2008. No data for 2009 were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
16	ITA				VL0612			3886			417	
16	ITA	GTR	DEMSP		VL0006				8548	9979	12285	
16	ITA	GTR	DEMSP		VL0612		164944	178522	76073	103953	103352	
16	ITA	GTR	DEMSP		VL1218		25926	7720	23894	18868	8189	
16	ITA	GTR	DEMSP		VL1824			1420				
16	ITA	LHP-LHM	CEP		VL0006				525	1162		
16	ITA	LHP-LHM	FINF		VL0612		16931	16553	14973	15019	21934	
16	ITA	LHP-LHM	FINF		VL1218		641					
16	ITA	LLD	LPF		VL1218		12401	3900	2924	3435	16936	
16	ITA	LLD	LPF		VL1824		36304	5756	1029	78320	12919	
16	ITA	LLS	DEMF		VL0006				1022	3942	1394	
16	ITA	LLS	DEMF		VL0612		26733	58661	12698	57631	9512	
16	ITA	LLS	DEMF		VL1218		21984	1640	3115	62773	18439	
16	ITA	LLS	DEMF		VL1824		1870					
16	ITA	OTB	DEMSP		VL1218		210042	238629	272220		263191	
16	ITA	OTB	DEMSP		VL1824		54367	13425			397440	
16	ITA	OTB	DEMSP		VL2440						693213	
16	ITA	OTB	DWSP		VL1824						15246	
16	ITA	OTB	DWSP		VL2440						41113	
16	ITA	OTB	MDDWSP		VL1218					285378	4336	
16	ITA	OTB	MDDWSP		VL1824		377936	418914	434834	549867	93949	
16	ITA	OTB	MDDWSP		VL2440		1116269	1161841	442196	1484331	225904	
16	ITA	OTM	MDPSP		VL1824				21611	26555	41792	
16	ITA	OTM	MDPSP		VL2440		5306		9096			
16	ITA	PS	LPF		VL1824						9763	
16	ITA	PS	SPF		VL0006						397	
16	ITA	PS	SPF		VL0612			8471		670	3127	
16	ITA	PS	SPF		VL1218		1772	1997	1355		2354	
16	ITA	PS	SPF		VL1824		17339	12429	7349	39307	11625	
16	ITA	PTM	SPF		VL1824			19612	72116	107330	38857	

5.65.3. Scientific surveys

5.65.3.1. Medits

5.65.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 16 the following number of hauls was reported per depth stratum (s. Tab. 5.65.3.1.1.1).

Tab. 5.65.3.1.1.1. Number of hauls per year and depth stratum in GSA 16, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA16_010-050	4	4	4	4	4	4	4	4	7	7	7	10	10	11	11	11
GSA16_050-100	9	8	8	8	8	8	7	8	11	12	12	20	22	23	23	23
GSA16_100-200	4	4	4	4	5	5	6	5	11	10	11	20	19	21	21	21
GSA16_200-500	10	11	11	12	11	11	11	11	19	18	26	37	31	27	27	27
GSA16_500-800	10	14	14	13	14	14	14	14	20	20	21	33	33	38	38	38

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.65.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.65.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the Norway lobster in GSA 16 was derived from the international survey Medits. Figure 5.65.3.1.3.1 displays the estimated trend in Norway lobster abundance and biomass in GSA 16. Both indices of stock abundance and biomass appear high and represent maximum values in 2009.

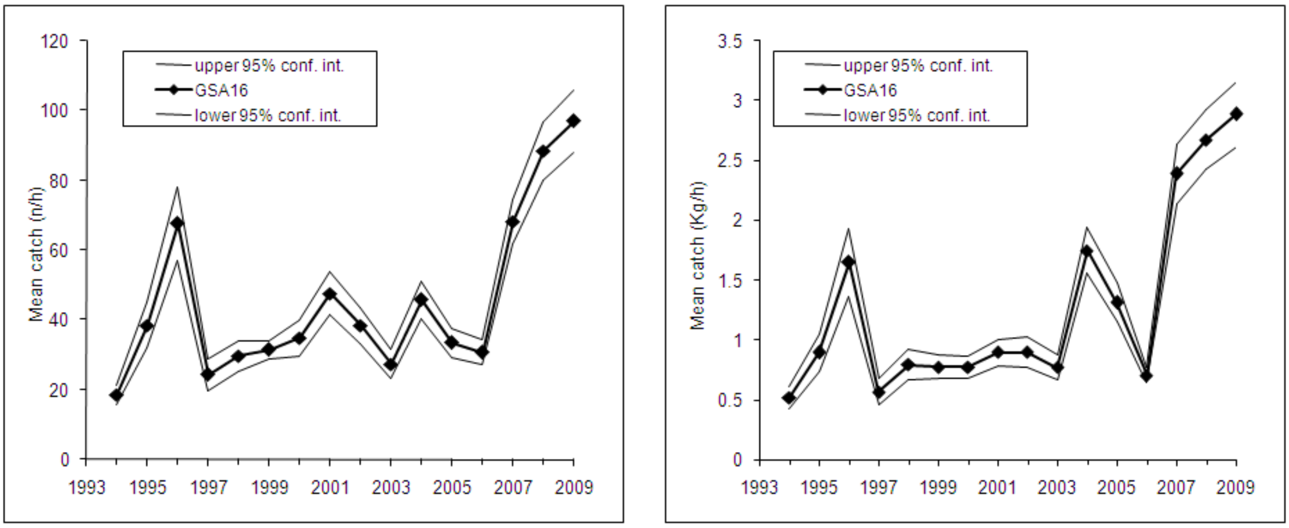


Fig. 5.65.3.1.3.1 Abundance and biomass indices of Norway lobster in GSA 16.

5.65.3.1.4. Trends in abundance by length or age

The following Fig. 5.65.3.1.4.1 and 2 display the stratified abundance indices of GSA 16 in 1994-2009.

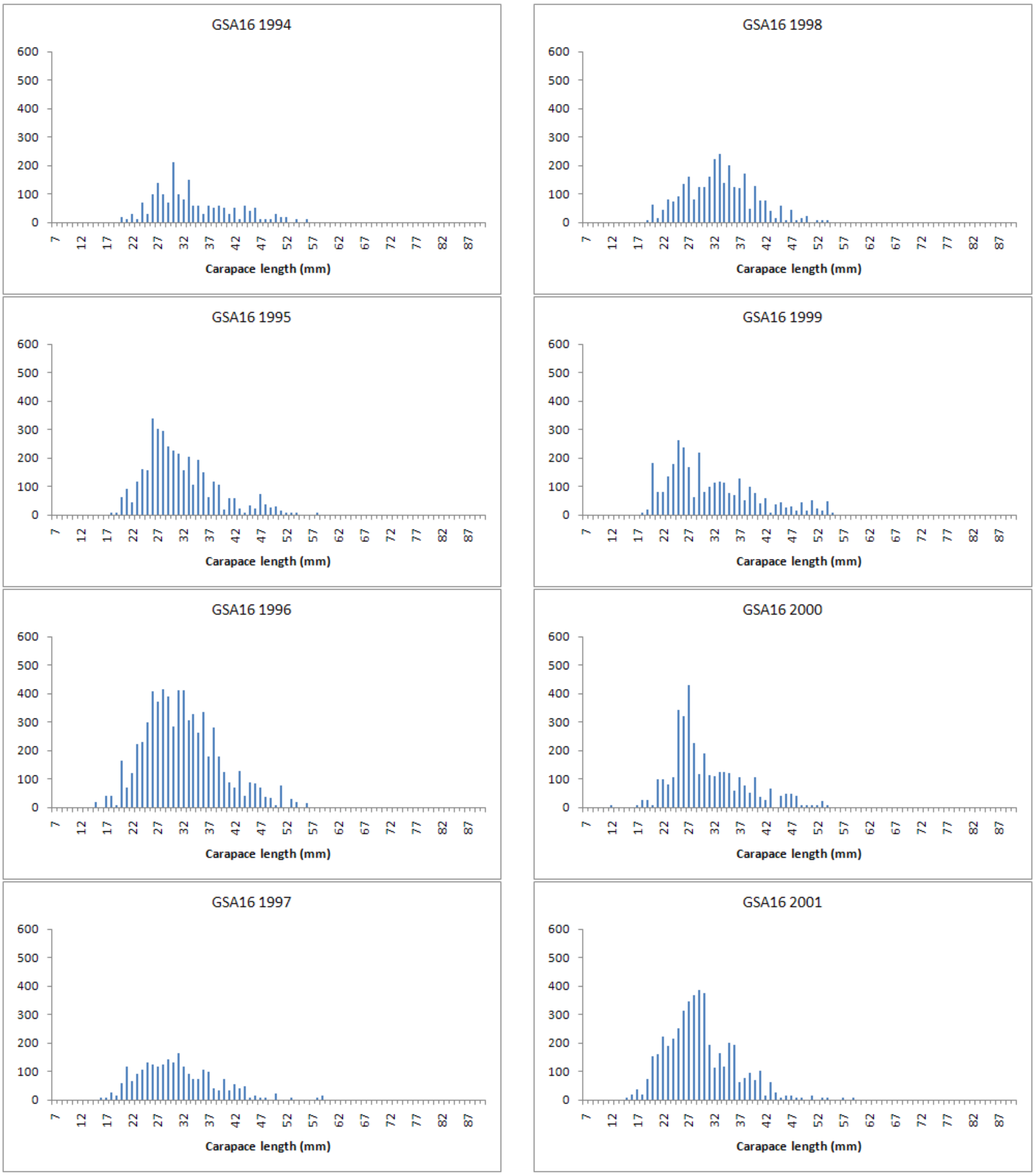


Fig. 5.65.3.1.4.1 Stratified abundance indices by size, 1994-2001.

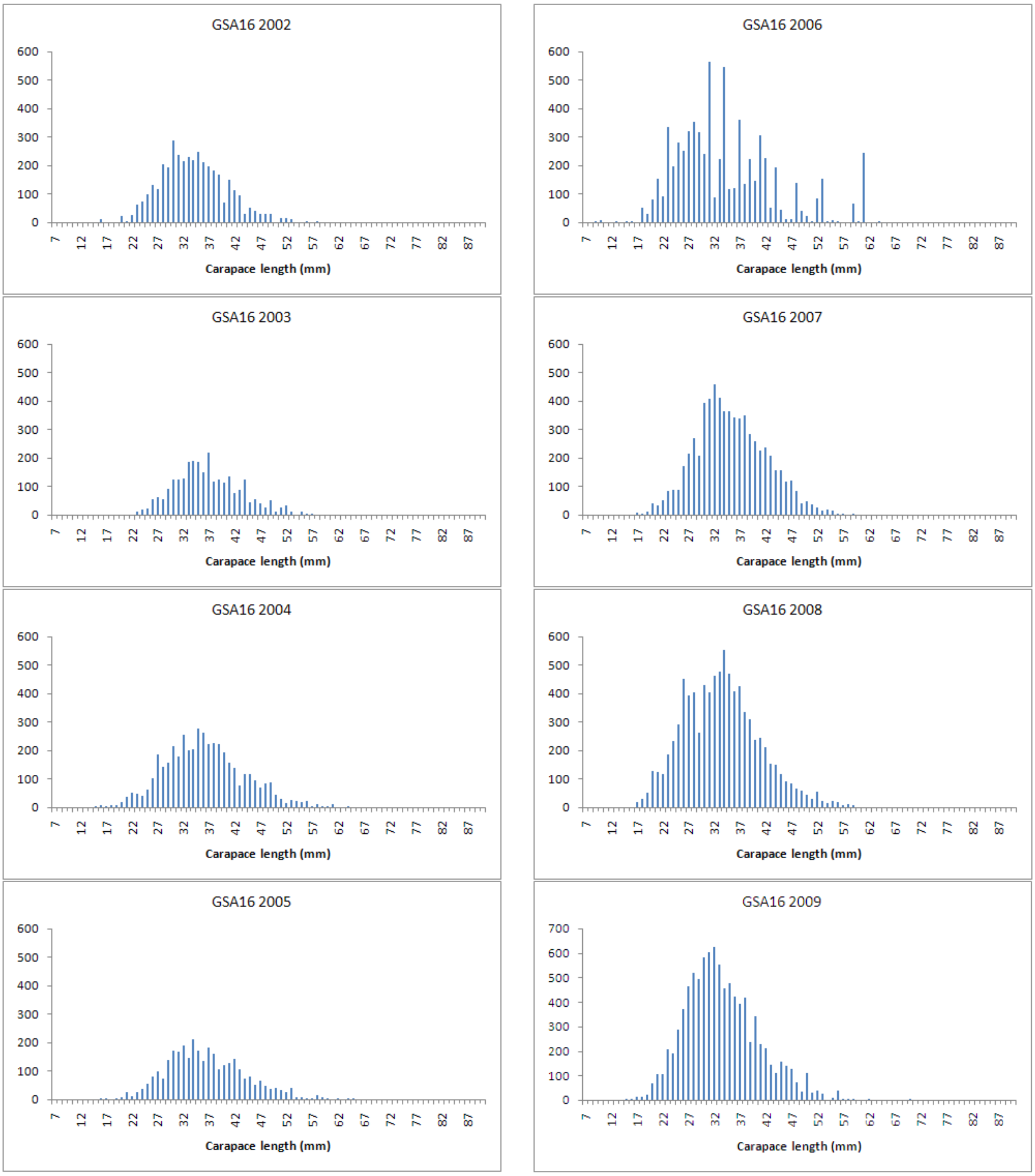


Fig. 5.65.3.1.4.2 Stratified abundance indices by size, 2002-2009.

5.65.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.65.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.65.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.65.5. Long term prediction

5.65.5.1. Justification

No forecast analyses were conducted.

5.65.5.2. Input parameters

No forecast analyses were conducted.

5.65.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for Norway lobster in GSA 16.

5.65.6. Scientific advice

5.65.6.1. Short term considerations

5.65.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses. However, survey indices of stock size appear high and represent maximum values in 2009.

5.65.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.65.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation in relation to proposed precautionary and target levels given the preliminary state of the data and analyses.

5.66. Stock assessment of Norway lobster in GSA 17

5.66.1. Stock identification and biological features

5.66.1.1. Stock Identification

Norway lobster in GSA 17 is considered a single stock unit shared among Albania, Croatia, Italy, Slovenia and Montenegro. The species is present between 30 to 400 m depth in the Adriatic. Major concentrations are found in the Pomo/Jabuka pit area. Rich fishing grounds can also be found in the areas of the Velebit channel, Kvarner and Kvarneric region. In the Southern Adriatic individuals on the *Nephrops* grounds are less densely concentrated.

5.66.1.2. Growth

Growth rates in Pomo pit are considered lower than in other areas. The different growth rate is likely to be related to less favourable environmental conditions in such area.

The estimated L/W relationship is a=0.000263 b=3.27

In the DCR frame, it is found the following set of growth parameters:
L_∞=58, K=0.249, t_0=-0.558

Other growth parameters found in literature in the area (IMBC *et al*., 1994):

Males	Linf=82.5	K= 0.l325	t_0= 0.28
Females	Linf=59.5	K= 0.45	t_0=0.06

5.66.1.3. Maturity

The species reaches sexual maturity at 3 years old at about Lm=32 mm CL. The fecundity at size was estimated by Froglia & Gramitto (1979, 1981) F= 0.0575* CL^2.942. The species' spawning season is between spring and summer with two main peaks.

5.66.2. Fisheries

5.66.2.1. General description of fisheries

In the Adriatic Sea, *N.norvegicus* is mainly caught with two types of gear: most of the individuals are caught with bottom trawl nets and the rest with traps (mainly in channel areas of the northern Adriatic). With the traditional trawl net with a cod end stretched mesh size of 40 mm is defined an Lc= 50-60 mm of TL (around 25-30 mm CL).

5.66.2.2. Management regulations applicable in 2009 and 2010

Landings minimum legal size:

ALBANIA: It is strictly prohibited to fish and sell any aquatic species less than the minimum regulatory size 30 cm as set out in Article 48.1 of Fisheries Regulations No.1 of 1997.

CROATIA:The Order of 1998 (145/98) and amended by the Order 101/02 on the Protection of Fish and Other Marine Organisms was adopted to determine the minimum sizes of certain species of fish. *Nephrops norvegicus*= 7 cm.

ITALY:The self-executing rules of Reg. EC 1626/1994 establish the minimum size to protect juveniles of *Nephrops norvegicus* over 20 mm Carapage length, 70 mm Total length.

SERBIA-MONTENEGRO: The minimum size is laid down as follows: 2. Decree on prohibition of capture and trade in fish juveniles, undersized fish and other marine organisms no. 10/2004.

SLOVENIA: *Nephrops norvegicus* - minimum 10 cm

CROATIA:Numerous regulations have been adopted in Croatia to regulate fishing gears' technical characteristics and their use with regard to commercial, small-scale and sport fishing. An Ordinance of 1996 on commercial fishing (46/96) prescribes, according to the type of license granted to a vessel, the quantities and types of gear that can be carried on board and used from that vessel. Mesh sizes of nets and other fishing gears as well as their area and time of use have also been determined in Regulations on Commercial Fishing of 2000 (83/2000). Also traps for Norwegian lobsters (*Nephrops norvegicus*) have been regulated.

5.66.2.3.Catches

5.66.2.3.1. Landings

Official data shows that in the last years the catches in the area were between 1,278 and 1,974 tons (Tab. 5.66.2.3.1.1).

Tab. 5.66.2.3.1.1 Landing (t) by country and fishing technique as reported through the official 2010 DCF data call. No 2009 data were submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
NEP	17	ITA								0			
NEP	17	ITA	GTR	DEMSP							0		
NEP	17	ITA	OTB	DEMSP				923	1573	1462	1259	1270	
NEP	17	ITA	OTB	MDDWSP				967	388	197	196	2	
NEP	17	ITA	OTM	MDPSP						0			
NEP	17	ITA	PS	LPF					0				
NEP	17	ITA	TBB	DEMSP				14	14	17	15	6	
Sum								1904	1975	1676	1470	1278	

For previous years, the information on total landings from the northern and central Adriatic is presented in Fig. 5.66.2.3.1.1.

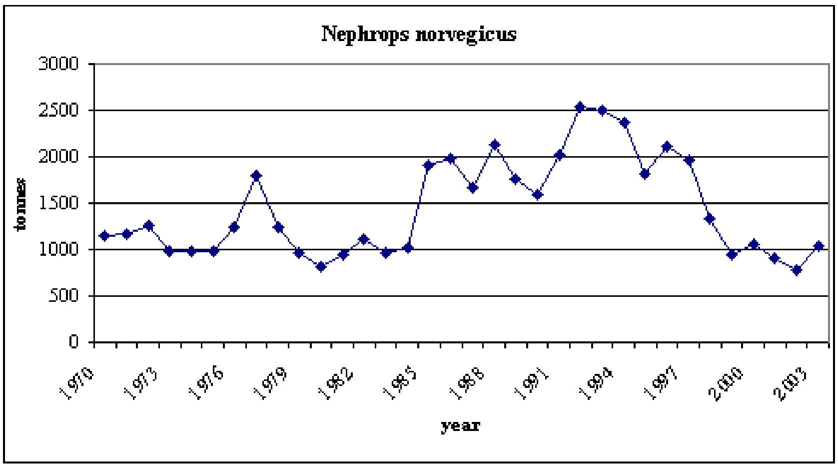


Fig. 5.66.2.3.1.1 Data FAO 1970-2004 of catches in Northern and Central Adriatic.

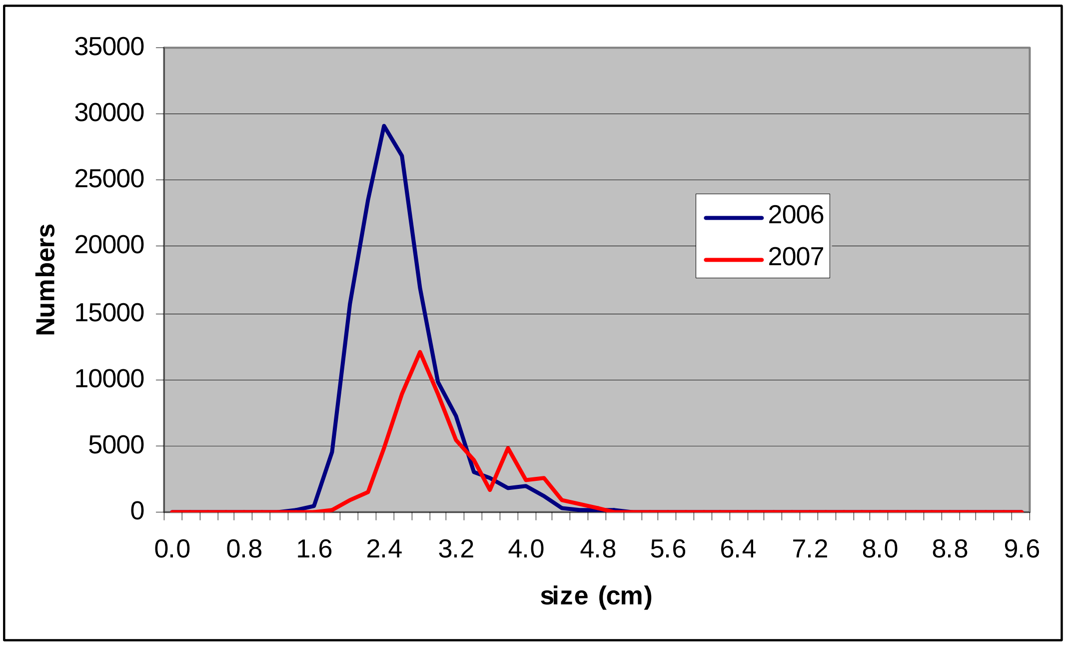


Fig. 5.66.2.3.1.2 Length composition of the commercial catches in numbers for 2006 and 2007(Official data).

5.66.2.3.2. Discards

No discard data were reported to SGMED.

5.66.2.4. Fishing effort

Fishing effort expressed in days of activity available from submitted official data seems very low considering the size of the fleets operating in the area and the commercial importance of the species in question. The number of vessels that targets this specific species is not specified.

Tab. 5.66.2.3.3.1 Fishing effort (kW*days) by country and fishing technique as reported through the official 2010 DCF data call. No 2009 data were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
17	ITA				VL0006				28839	19464	25018	
17	ITA				VL0612		585226	426770	538249	418073	245003	
17	ITA				VL1218		21467	23352				
17	ITA				VL2440			4097		7903		
17	ITA	DRB	MOL		VL0612		19073					
17	ITA	DRB	MOL		VL1218		581702	484258	407953	612211	492480	
17	ITA	FPO	DEMSP		VL0006				130			
17	ITA	FPO	DEMSP		VL0612		19874	17355	9999	9718	18643	
17	ITA	FYK	DEMSP		VL0006				0	0	0	
17	ITA	FYK	DEMSP		VL0612		6671	333	5572	34133	14013	
17	ITA	GND	SPF		VL0612			214				
17	ITA	GNS	DEMSP		VL0006				27244	4459	16709	
17	ITA	GNS	DEMSP		VL0612		113579	97152	43173	36087	33960	
17	ITA	GNS	DEMSP		VL1218		24644	15559	7559			
17	ITA	GTR	DEMSP		VL0006				0	0		
17	ITA	GTR	DEMSP		VL0612		14415	25334	31121	34778	26522	
17	ITA	GTR	DEMSP		VL1218			7215				
17	ITA	LLD	LPF		VL0612		7472	2384			5843	
17	ITA	LLD	LPF		VL1218		961	9928	6181	3765	416	
17	ITA	LLS	DEMF		VL0612				529	498		
17	ITA	OTB	DEMSP		VL0612		143723	70376	46397	71355	67595	
17	ITA	OTB	DEMSP		VL1218		910397	713888	599979	686576	595477	
17	ITA	OTB	DEMSP		VL1824		822314	379538	639196	779138	713636	
17	ITA	OTB	DEMSP		VL2440		479467	305876	303593	249435	249021	
17	ITA	OTB	MDDWSP		VL1824			455880				
17	ITA	OTB	MDDWSP		VL2440			101556	85117	81784	15108	
17	ITA	OTM	MDPSP		VL0612			666				
17	ITA	OTM	MDPSP		VL2440				963			
17	ITA	PS	SPF		VL0612		15395	11368				
17	ITA	PS	SPF		VL1218		1912	7297	13939	3958	1374	
17	ITA	PS	SPF		VL2440					15557		
17	ITA	PTM	SPF		VL1218		9255	28121	1056		11264	
17	ITA	PTM	SPF		VL1824		446896	309738	331008	393874	93255	
17	ITA	PTM	SPF		VL2440		170745	183571	198308	225578	385407	
17	ITA	TBB	DEMSP		VL1218		32478	16587	30023	74266	54618	
17	ITA	TBB	DEMSP		VL1824		229009	266268	365432	304104	172961	
17	ITA	TBB	DEMSP		VL2440		104553	93303	108658	138558	267487	
17	SVN	FPO	DEMSP	NA	VL0006			738	788	695	1124	382
17	SVN	FPO	DEMSP	NA	VL0012			846	788	695	1145	382
17	SVN	FPO	DEMSP	NA	VL0612			107			20	
17	SVN	FPO	DEMSP	NA	VL1218						6632	11027
17	SVN	FPO	DEMSP	NA	VL1224						6632	11027
17	SVN	FYK	DEMSP	NA	VL0006			165	495	637	18	458
17	SVN	FYK	DEMSP	NA	VL0012			165	554	637	18	458
17	SVN	FYK	DEMSP	NA	VL0612				59			
17	SVN	GND	SPF	20D40	VL0012			1135	227	92	219	141
17	SVN	GND	SPF	20D40	VL0612			1135	227	92	219	141
17	SVN	GND	SPF	20D40	VL1218					355		
17	SVN	GND	SPF	20D40	VL1224					355		
17	SVN	GNS	DEMSP	16D20	VL0006			3624	3368	4616	4970	6367
17	SVN	GNS	DEMSP	16D20	VL0012			20524	20108	20482	47601	53623
17	SVN	GNS	DEMSP	16D20	VL0612			16900	16739	15893	42671	47256
17	SVN	GNS	DEMSP	16D20	VL1218			67	996	8602	4938	861
17	SVN	GNS	DEMSP	16D20	VL1224			67	996	8602	4938	861
17	SVN	GTR	DEMSP	50D100	VL0006			2767	1608	3570	7475	6644
17	SVN	GTR	DEMSP	50D100	VL0012			29427	37010	75895	81751	78489
17	SVN	GTR	DEMSP	50D100	VL0612			26660	35402	72386	74276	71844
17	SVN	GTR	DEMSP	50D100	VL1218			15970		7548	5137	1387
17	SVN	GTR	DEMSP	50D100	VL1224			15970		7548	5137	1387
17	SVN	LHP-LHM	CEP	NA	VL0006							11
17	SVN	LHP-LHM	CEP	NA	VL0012						3	11
17	SVN	LHP-LHM	CEP	NA	VL0612						3	
17	SVN	LHP-LHM	FINF	NA	VL0006					4	3	9
17	SVN	LHP-LHM	FINF	NA	VL0012			10		4	20	12
17	SVN	LHP-LHM	FINF	NA	VL0612			10			17	4
17	SVN	LLS	DEMSP	NA	VL0006			22	13	36	31	22
17	SVN	LLS	DEMSP	NA	VL0012			153	637	36	40	421
17	SVN	LLS	DEMSP	NA	VL0612			131	624		8	399
17	SVN	LLS	DEMSP	NA	VL1218					27		
17	SVN	LLS	DEMSP	NA	VL1224					27		
17	SVN	OTB	DEMSP	40D50	VL0006			17				4
17	SVN	OTB	DEMSP	40D50	VL0012			17615	19313	20311	18128	14912
17	SVN	OTB	DEMSP	40D50	VL0612			18935	27569	34965	37112	40305
17	SVN	OTB	DEMSP	40D50	VL1218			41539	54928	76356	79234	84796
17	SVN	OTB	DEMSP	40D50	VL1224			41539	54928	76356	79234	84796
17	SVN	OTB	DEMSP	40D50	VL2440					600	350	
17	SVN	OTM	MDPSP	20D40	VL1218						47	196
17	SVN	OTM	MDPSP	20D40	VL1224						47	196
17	SVN	OTM	MDPSP	20D40	VL2440							550
17	SVN	PS	SPF	14D16	VL0006							3
17	SVN	PS	SPF	14D16	VL0012			3169	4648	6209	4073	3009
17	SVN	PS	SPF	14D16	VL0612			3169	4648	6209	4073	3005
17	SVN	PS	SPF	14D16	VL1218			14080	15883	11865	12994	20598
17	SVN	PS	SPF	14D16	VL1224			14080	15883	11865	12994	20598
17	SVN	PTM	SPF	20D40	VL2440			100585	91719	110404	69808	102116

5.66.3. *Scientific surveys*

5.66.3.1. Medits

5.66.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 17 the following number of hauls was reported per depth stratum (s. Tab. 5.66.3.1.1.1).

Tab. 5.66.3.1.1.1. Number of hauls per year and depth stratum in GSA 17, 2002-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA17_010-050									57	45	47	61	49	52	51	49
GSA17_050-100									54	36	37	62	38	32	37	37
GSA17_100-200									50	27	22	43	21	24	23	22
GSA17_200-500									9	7	5	7	5	5	5	5
GSA17_500-800									1	1						

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length

frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.66.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.66.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the Norway lobster in GSA 17 was derived from the international survey Medits. Figure 5.66.3.1.3.1 displays the estimated trend in Norway lobster abundance and biomass in GSA 17.

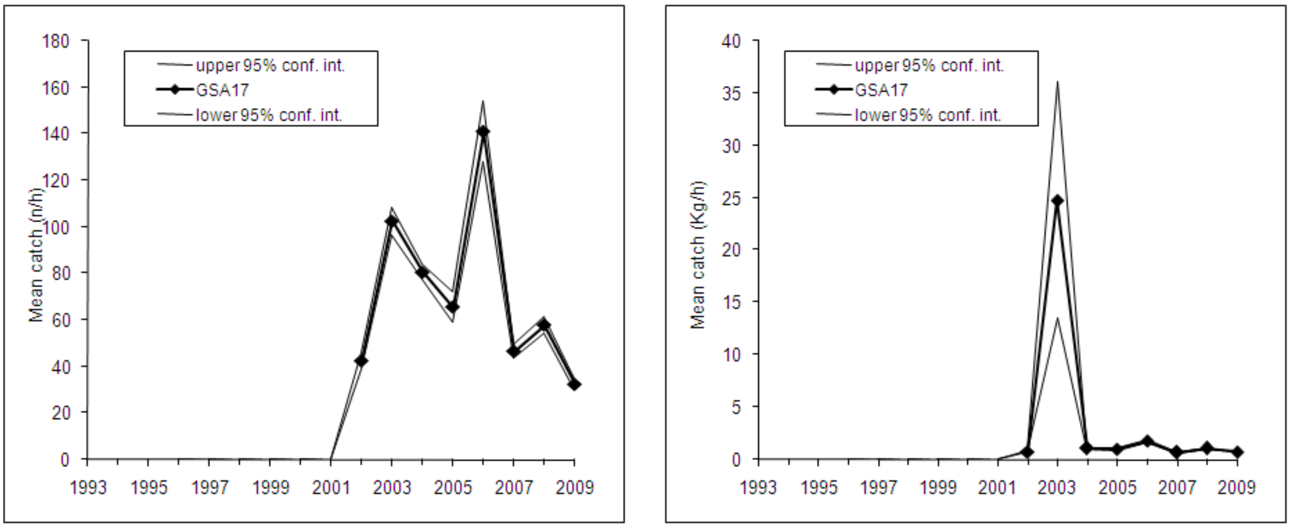


Fig. 5.66.3.1.3.1 Abundance and biomass indices of Norway lobster in GSA 17. The 2003 survey data on catch weights require a thorough review due to outlier observed.

Figure 5.66.3.1.3.2 displays the distribution pattern of the survey hauls and abundance per station. However, the annual survey data in many years reported only cover the western part of GSA17 as hauls data from the eastern part of the GSA17 are only included in the submitted database in 2002 and 2005. This inconsistency prevents comparisons of abundance indexes over the time series.

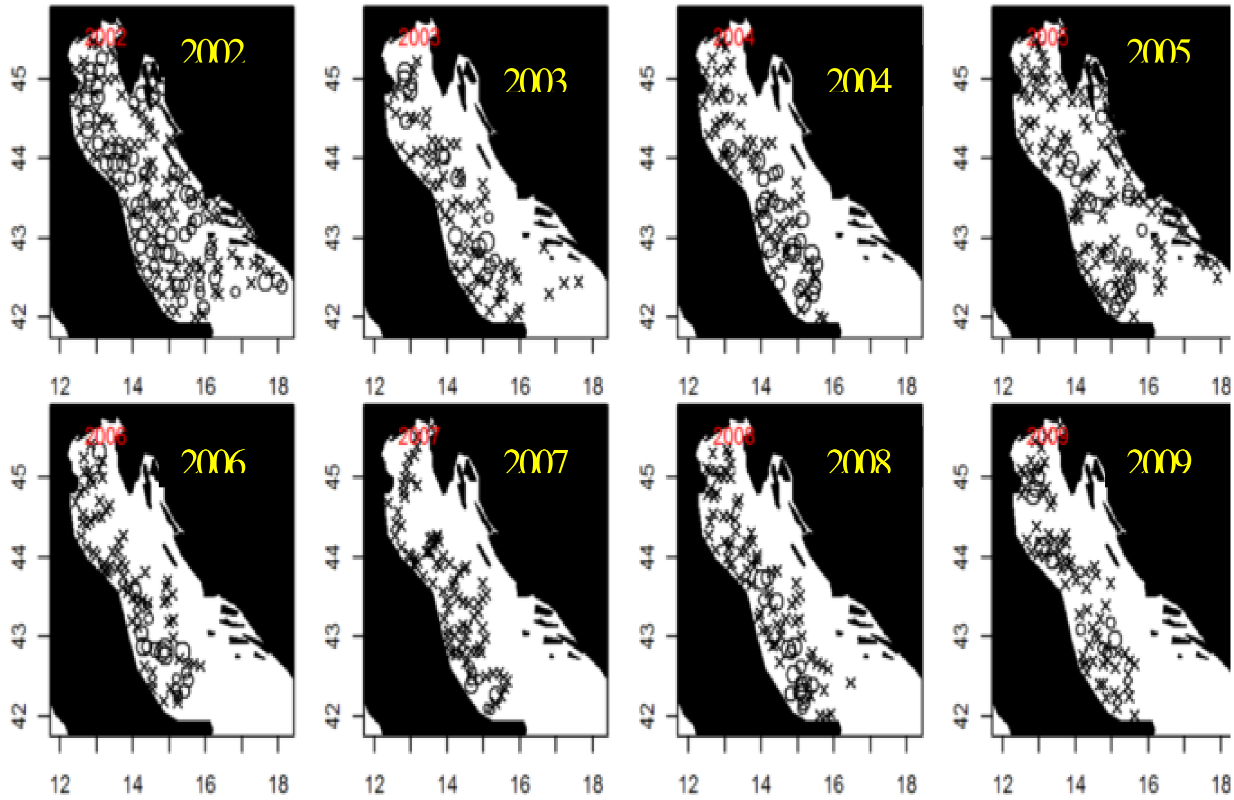


Fig. 5.66.3.1.3.2 Geographic distribution patterns of Norway lobster catches in GSA 17 as included in the MEDITS data base.

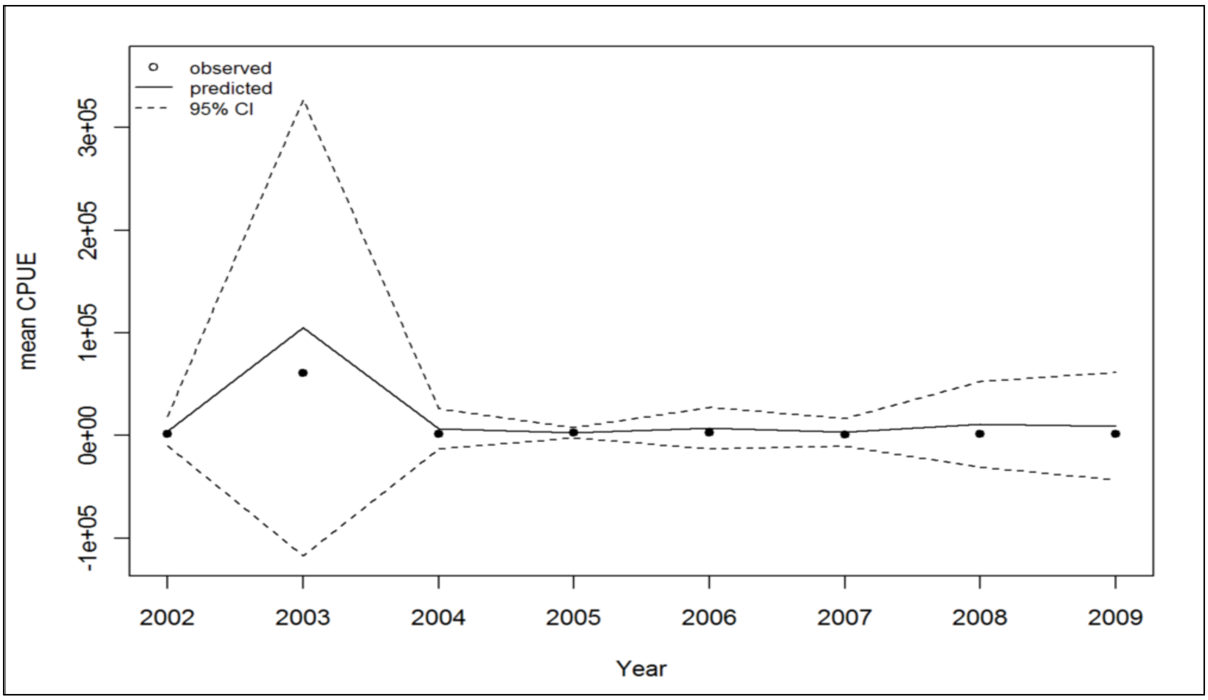


Fig. 5.66.3.1.3.3 Stratified biomass indices as derived from the MEDITS data base, 2002-2009.

5.66.3.1.4. *Trends in abundance by length or age*

The following Fig. 5.66.3.1.4.1 display the stratified abundance indices of GSA 17 in 2002-2009.

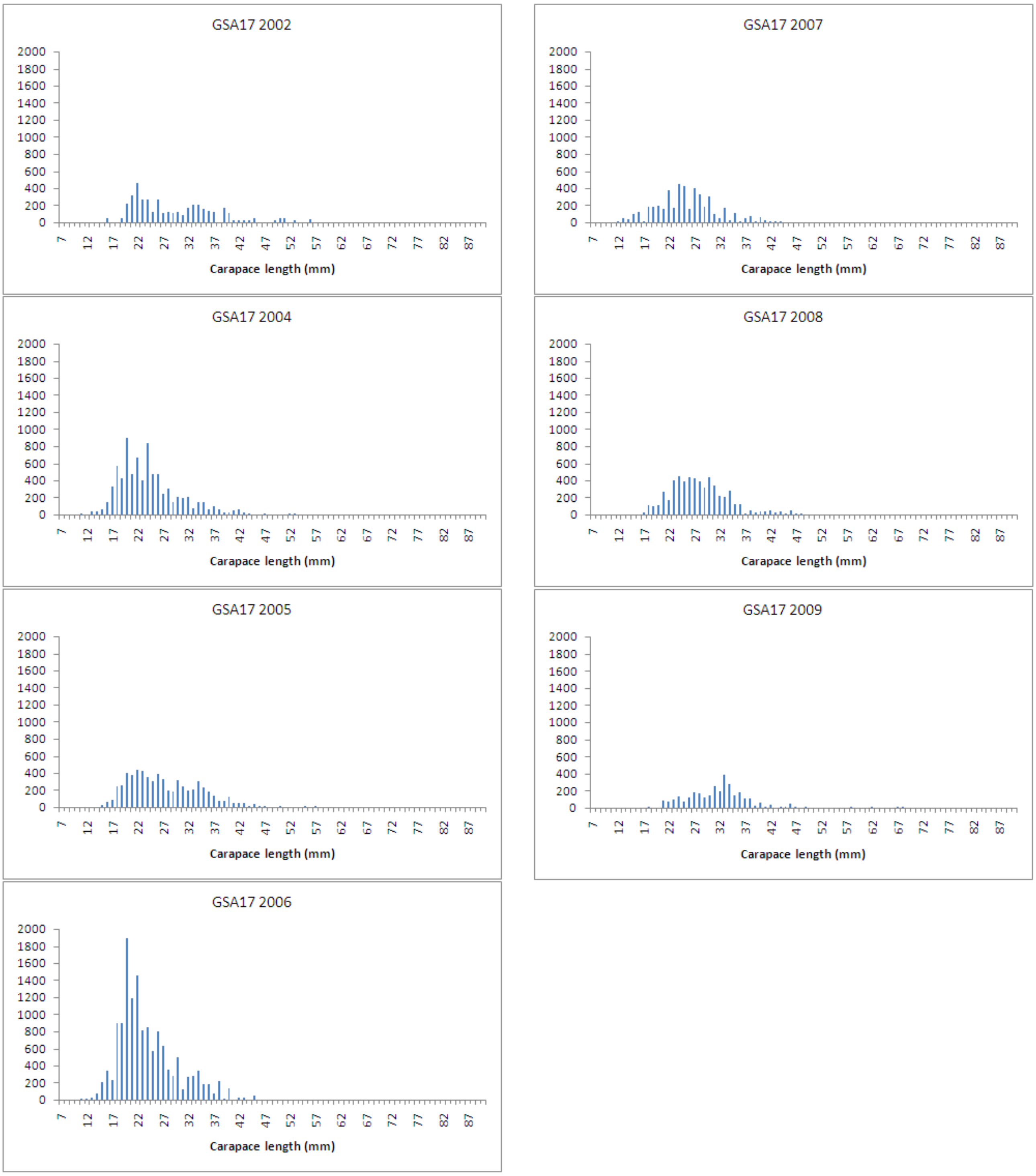


Fig. 5.66.3.1.4.1 Stratified abundance indices by size, 2002, 2004-2009.

5.66.3.1.5. *Trends in growth*

No analyses were conducted during SGMED-10-02.

5.66.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.66.4. Assessment of historic stock parameters

5.66.4.1.Method 1: Length Cohort Analysis

5.66.4.1.1. Justification

A length cohort analysis was performed for the estimation of the vectors of fishing mortality. The choice was conditioned by the lacking of a long time series that makes unsuitable the utilization of a more precise and less biased approach. The direct ageing is not possible for Norway lobster due to the lack of hard structures showing annual or seasonal rings. The analyses were performed even though there was a general agreement about the poor data quality and regarding the lacking of consistency between growth parameters and data.

5.66.4.1.2. Input parameters

Having only 2 years of size structure of the commercial catch, a pseudo-cohort analysis assuming equilibrium was run.

Tab. 5.66.4.1.2.1 Biological parameters and used to run the VIT model.

$L\infty$ = 58
K= 0.249

To=-0.558

L/W a=0.000401 b=3.124

M=0.4

Tab. 5.66.4.1.2.2 Length compositions of the landings in 2006 and 2007.

CL	2006 N	2007 N
14	94	
16	445	
18	4589	127
20	15618	895
22	23531	1445
24	29064	4757
26	26802	8929
28	16873	12011
30	9793	8926
32	7182	5434
34	2990	3924
36	2520	1652
38	1789	4825
40	1996	2391
42	1157	2596
44	289	832
46	131	613
48	150	307
50	199	29
52	66	
54	70	
56	9	
58	72	
60	84	

5.66.4.1.3. Results

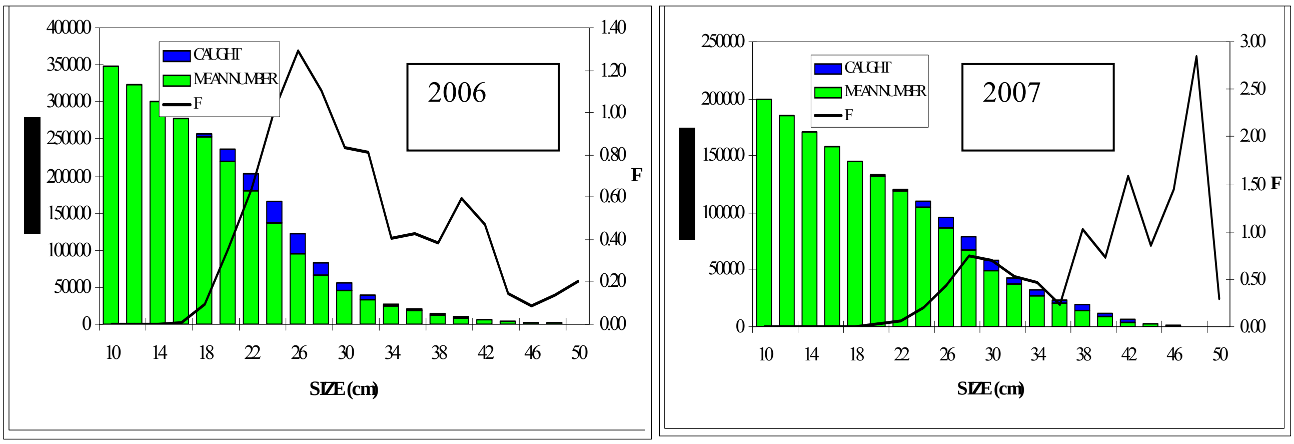


Fig. 5.66.4.1.3.1 VIT assessment results.

Two completely different F vectors were obtained for the two analysed years, in 2006 showing a peak on juveniles (almost 2 years old individuals) while in 2007 with higher F for older age classes. Weighted mean F for the two years were as follows:

Mean F(2006)= 0.86   Mean F(2007)= 0.42

5.66.5. Long term prediction

5.66.5.1. Justification

A yield per recruit analysis structured by size was performed for the estimation of long term relative yields at different levels of exploitation and for the definition of some reference points related to yields maximization and sustainability (VIT). The chosen reference points were $F_{0.1}$, F_{max} and F30%SSB.

5.66.5.2. Input parameters

The growth parameters used in the analysis were those available for the area reported above. A constant value of 0.4 was hypothesized for Natural Mortality.

5.66.5.3. Results

The Y/R curve has shown an almost flat shape over certain F values, with a maximum at relatively high F rates.

The following RPs were derived:

F_{max}=2.44
$F_{0.1}$ = 0.44
F30%SSB = 0.54

SGMED-10-02 notes the flat shape of the YpR curve and thus considers such estimated reference points as biased and not applicable as management reference points consistent with high long term yields.

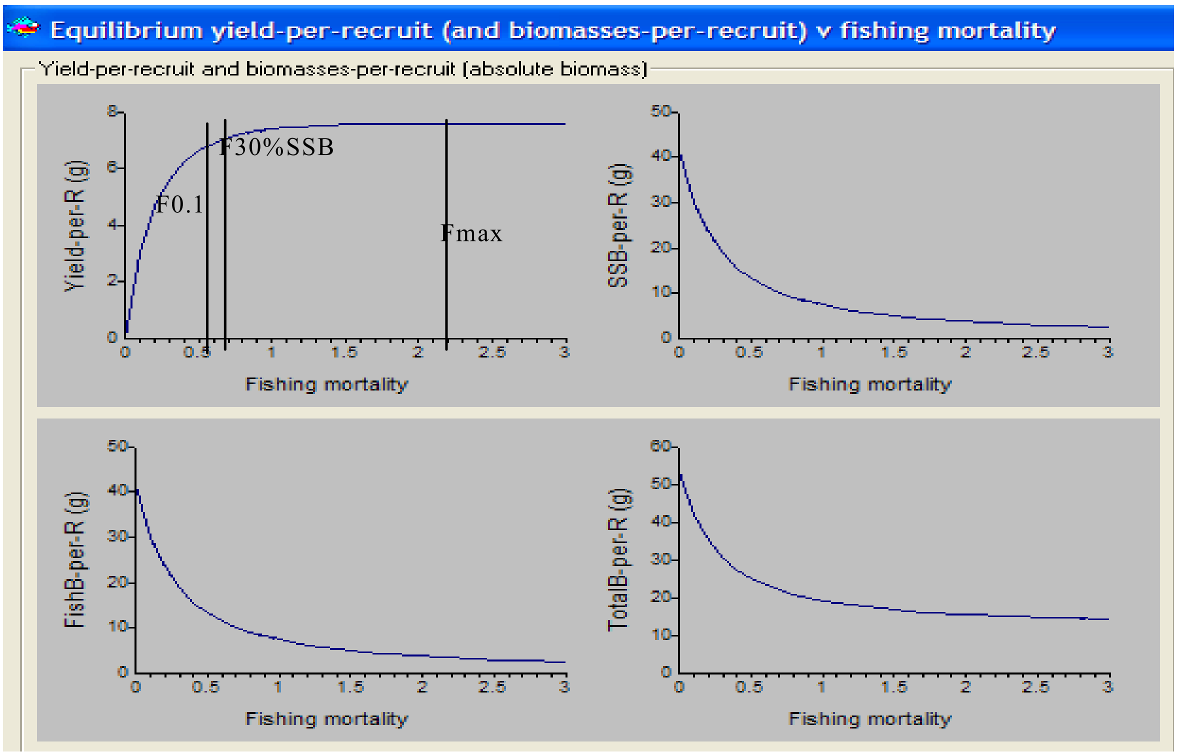


Fig. 5.66.5.3.1. Yield per recruit, Fish Biomass per recruit, SSB/R and Total Biomass per recruit analyses for *Nephrops norvegicus*. The values of F corresponding to the 3 defined RPs are shown.

5.66.6. *Data quality*

Data on size structure of the commercial catch was supplied only for the years 2006 and 2007. The size structures have shown a quite different distribution, with the year 2006 showing a unimodal distribution (peak in 24 mm) and a long tail to the right, that includes several big-sized individuals up to 95 mm, and the 2007 structure showing a bimodal distribution, with a main peak in 28 mm, and including individuals of maximum size of 5 0mm. With the available information, it is impossible to hypothesize any explanation for such marked differences, that may be only explained in the case of occurrence of drastic changes in the spatial distribution of the fleet or in changes in the sampling design.

Such extremely different size structures, the uncertainties on levels of effort, structure of the landings and the shortage of time series, prevents the performance of a reliable assessment of the status of exploitation of the stock. In any case, and only with the aim of comparing the perceptions of the state of the stock derived from the use of the data corresponding to the only 2 years of size distribution data, the parameters available for the area were used for the performance of the yield per recruit and a length cohort analysis. It was however observed a lacking of consistence among the parameters supplied and the size of the landed individuals in 2006, that in many cases are much larger (up to 40% higher) than the estimated L_∞ value.

The average fishing mortality rates estimated for the two years for the ages 2-8 resulted very different and especially different distribution by age are observed between the two years, with much higher values in ages 2 and 3 in 2006 and in ages 7 and 8 in 2007. Having defined a value for the RP $F_{0.1}$ of 0.44, such results would suggest that in one case the stock is highly exploited while in the other year the current F is under the reference value used as a proxy of F_{MSY}. This is unlikely without a drastic change in spatial distribution pattern of fishing effort from 2006 to 2007.

In conclusion, it is necessary to stress that the performed analyses were done exclussively for demonstrating the misleading consequences of the use of such poor and unconsistent data and parameters. In fact, the available data precludes any assessment of the status of exploitation of the stocks.

The WG encourages a complete revision of the data (i.e. size structures) and the checking of the consistency of biological parameters with the observed size distributions in the catches. The WG would very much appreciate for the next meetings the provision of the whole time series of trawl MEDITS surveys (1994-2010) and the total coverage of the GSA17 (eastern and western part) and correct information about the commercial fishery (number of vessels of each fleet targeting the species, total landings per year, fishing areas and on any shift that might be occurred along time, accurate data on size structure of the landings, etc). Only if and when such information will be available, an assessments of this important commercial stock will be possible.

5.66.7. *Scientific advice*

5.66.7.1. Short term considerations

5.66.7.1.1. *State of the spawning stock size*

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.66.7.1.2. *State of recruitment*

SGMED-10-02 is unable to provide any scientific advice of the state of recruitment given the preliminary state of the data and analyses.

5.66.7.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of exploitation given the preliminary state of the data and analyses.

5.67. Stock assessment of Norway lobster in GSA 18

SGMED-10-02 did not assess this stock in 2010 but represents the assessment conducted by SGMED-09-02 in 2009 with few data updates (fisheries and surveys) where available and appropriate.

5.67.1. Stock identification and biological features

5.67.1.1. Stock Identification

No information was documented during SGMED-10-02.

5.67.1.2. Growth

No information was documented during SGMED-10-02.

5.67.1.3. Maturity

No information was documented during SGMED-10-02.

5.67.2. Fisheries

5.67.2.1. General description of fisheries

No information was documented during SGMED-10-02.

5.67.2.2. Management regulations applicable in 2009 and 2010

No information was documented during SGMED-10-02.

5.67.2.3. Catches

5.67.2.3.1. Landings

Tab. 5.67.2.3.1.1 lists the trend in reported landings by fishing technique. The data were reported to SGMED-10-02 through the Data Collection Regulation. The landings were mainly taken by demersal otter trawls.

Tab. 5.67.2.3.1.1 Annual landings (t) by fishing technique in GSA 18 as reported through the official 2010 DCF data call, 2004-2008. No 2009 data were submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
NEP	18	ITA								0			
NEP	18	ITA	GNS	DEMSP					2	10	15	10	
NEP	18	ITA	GNS	SLPF								0	
NEP	18	ITA	OTB	DEMSP				50	13	179	360	927	
NEP	18	ITA	OTB	DWSP								2	
NEP	18	ITA	OTB	MDDWSP				1169	1183	1258	940	76	
Sum								1219	1198	1447	1315	1015	

5.67.2.3.2. Discards

According to information available to the SGMED-10-02 no catches of Norway lobster were discarded by the Italian fleet.

5.67.2.3.3. Fishing effort

The trends in fishing effort by fishing technique reported to SGMED-10-02 are listed in Tab. 5.67.2.3.3.1.

Tab. 5.67.2.3.3.1 Trends in annual fishing effort (kW*days) by fishing technique deployed in GSA 18 as reported through the official 2010 data call, 2004-2008. No 2009 data were submitted by the Italian authorities.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
18	ITA				VL0006						653	
18	ITA				VL1218				18973			
18	ITA	DRB	MOL		VL1218		31755	15206	60312	29038	24106	
18	ITA	GNS	DEMSP		VL0006				0	0	0	
18	ITA	GNS	DEMSP		VL0612		79455	107014	73603	59052	76376	
18	ITA	GNS	DEMSP		VL1218				11360			
18	ITA	GTR	DEMSP		VL0006				0	767	3639	
18	ITA	GTR	DEMSP		VL0612		9276	16931	947		48849	
18	ITA	LHP-LHM	CEP		VL0006						1115	
18	ITA	LHP-LHM	CEP		VL0612				0			
18	ITA	LLD	LPF		VL0006						1453	
18	ITA	LLD	LPF		VL0612				0		1686	
18	ITA	LLD	LPF		VL1218			4999		3454		
18	ITA	LLS	DEMF		VL0006				1031	0	731	
18	ITA	LLS	DEMF		VL0612		2168	8862	8103	21686	24959	
18	ITA	LLS	DEMF		VL1218			4999	7077	43626	84915	
18	ITA	OTB	DEMSP		VL0612		31970	31096	30666	13651	27993	
18	ITA	OTB	DEMSP		VL1218				566531		485808	
18	ITA	OTB	DEMSP		VL1824						182427	
18	ITA	OTB	DEMSP		VL2440		36432				122656	
18	ITA	OTB	MDDWSP		VL0612		1409					
18	ITA	OTB	MDDWSP		VL1218		426469	539707		486560	49978	
18	ITA	OTB	MDDWSP		VL1824		390285	349132	553919	455935	44323	
18	ITA	OTB	MDDWSP		VL2440		339413	244695	123388	144908	4025	
18	ITA	PS	SPF		VL2440					27636	10183	
18	ITA	PTM	SPF		VL2440		74992	112819	141218	191256	128292	

5.67.3. Scientific surveys

5.67.3.1. Medits

5.67.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 18 the following number of hauls was reported per depth stratum (s. Tab. 5.67.3.1.1.1).

Tab. 5.67.3.1.1.1. Number of hauls per year and depth stratum in GSA 18, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA18_010-050	14	15	15	14	14	14	14	15	13	13	12	9	10	11	10	10
GSA18_050-100	14	14	14	15	15	15	15	14	21	21	23	16	15	15	14	13
GSA18_100-200	24	23	23	23	23	23	23	23	34	31	32	25	25	23	22	25
GSA18_200-500	10	10	10	10	10	10	10	10	15	15	16	10	10	9	8	11
GSA18_500-800	10	10	10	10	10	10	10	10	14	14	14	7	7	7	5	6

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:
A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.67.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.67.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the Norway lobster in GSA 18 was derived from the international survey Medits. Figure 5.67.3.1.3.1 displays the estimated trend in Norway lobster abundance and biomass in GSA 18.

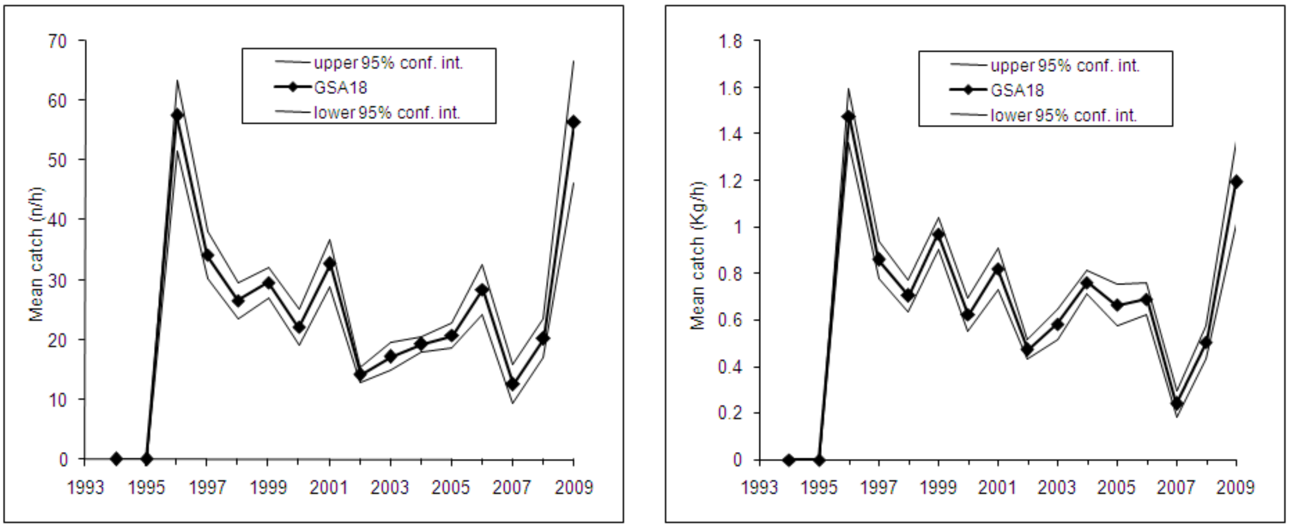


Fig. 5.67.3.1.3.1 Abundance and biomass indices of Norway lobster in GSA 18.

5.67.3.1.4. Trends in abundance by length or age

The following Fig. 5.67.3.1.4.1 and 2 display the stratified abundance indices of GSA 18 in 1996-2009.

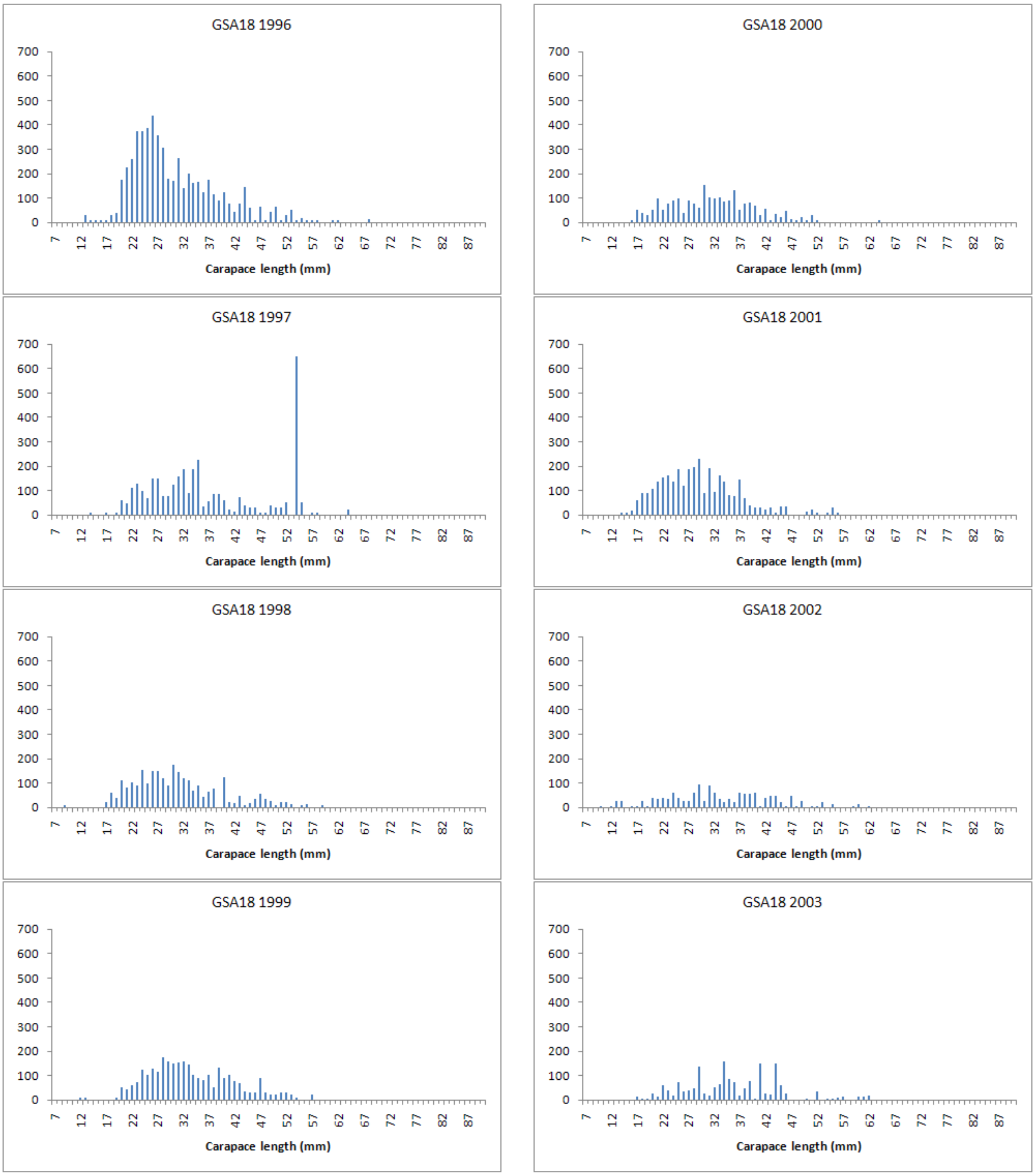


Fig. 5.67.3.1.4.1 Stratified abundance indices by size, 1996-2003.

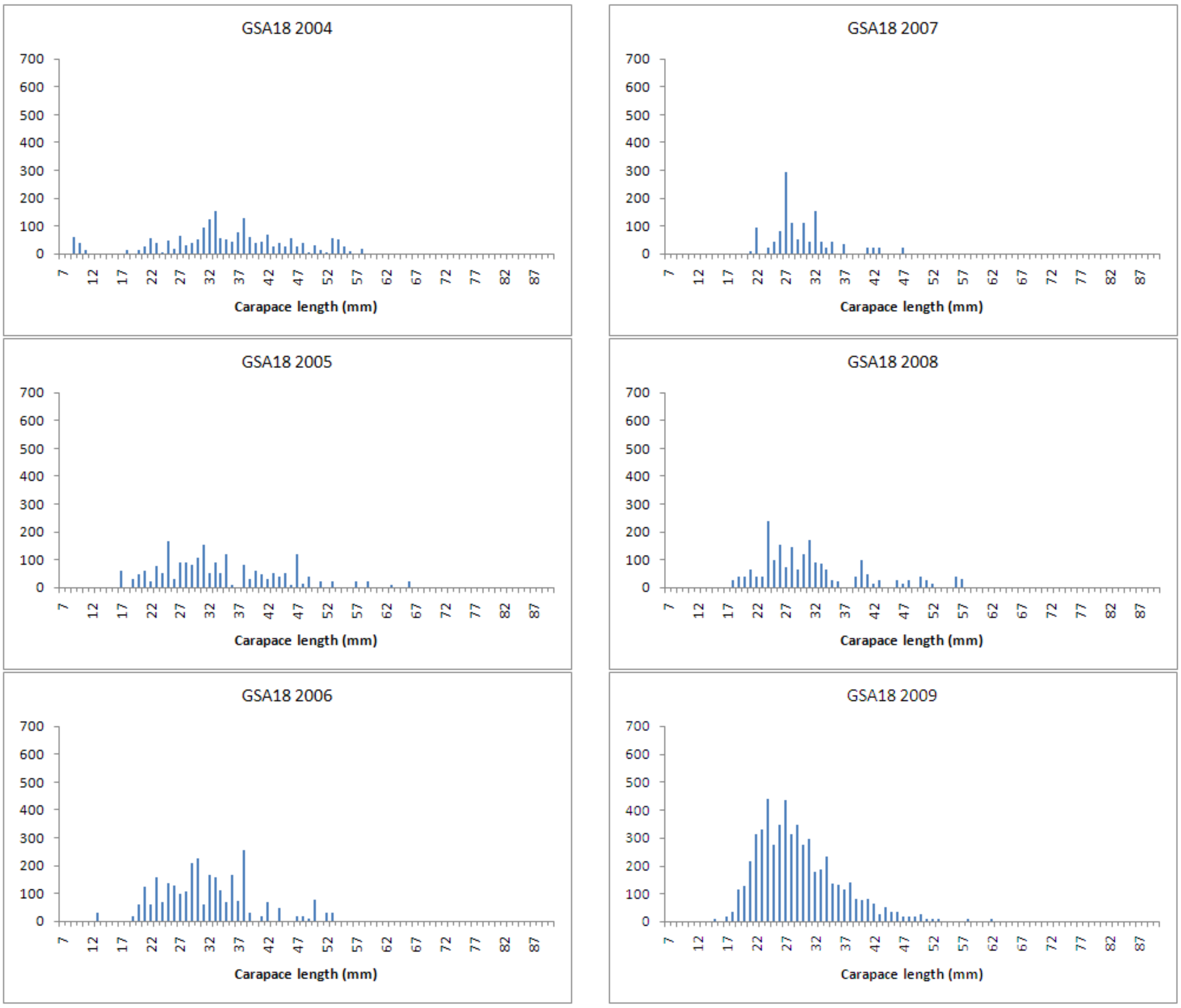


Fig. 5.67.3.1.4.2 Stratified abundance indices by size, 2004-2009.

5.67.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.67.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.67.4. Assessment of historic stock parameters

SGMED-10-02 did not undertake any analytical assessment.

5.67.5. Long term prediction

5.67.5.1. Justification

No forecast analyses were conducted.

5.67.5.2. Input parameters

No forecast analyses were conducted.

5.67.5.3. Results

Given the preliminary state of the data and analyses SGMED-10-02 is not in the position to provide a long term prediction of catch and stock biomass for Norway lobster in GSA 18.

5.67.6. Scientific advice

5.67.6.1. Short term considerations

5.67.6.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.67.6.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.67.6.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the exploitation given the preliminary state of the data and analyses.

5.68. Stock assessment of striped mullet in GSA 05

5.68.1. Stock identification and biological features

5.68.1.1. Stock Identification

The GFCM GSA 05 includes the waters around the Balearic Islands. This Archipelago is constituted by the islands of Mallorca, Menorca, Ibiza and Formentera. From official landings, the striped mullet (*Mullus surmuletus*) represents the following percentages by island: 94.8% Mallorca, 2.7% Menorca and 2.5% Ibiza-Formentera. The present assessment has been performed considering exclusively data from Mallorca because: 1) reliability and availability of fishery statistics; and 2) both length and biological (growth, maturity, and length-weight) samplings were carried out in this island. Hence, it must be taken into account that the present assessment represents approximately 95% of the total landings for GSA 05. Due to a lack of information about the structure of striped mullet population in the western Mediterranean, this stock was assumed to be confined within the GSA 05 boundaries.

5.68.1.2. Growth

No analyses were conducted during SGMED-10-02.

5.68.1.3. Maturity

No analyses were conducted during SGMED-10-02.

5.68.2. Fisheries

5.68.2.1. General description of fisheries

In the Balearic Islands (GSA 05), commercial trawlers employ up to four different fishing tactics (Palmer et al. 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Guijarro and Massutí 2006; Ordines et al. 2006). Vessels mainly target striped mullet (*Mullus sumuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered monospecific.

The species assessed, the striped red mullet, is one of the most important target species in the trawl fishery working on the continental shelf off Mallorca (35-40 vessels). A fraction of the small-scale fleet (~100 boats) also directs to this species during the second semester of the year (July-December), using both trammel nets and gillnets.

5.68.2.2. Management regulations applicable in 2009 and 2010

Fishing license: fully observed.
Engine power limited to 316 KW or 500 CV: not observed.
Mesh size in the cod-end (40 mm stretched): fully observed.
Fishing forbidden upper 50 m depth: not fully observed.
Time at sea (12 hours per day and 5 days per week): fully observed.

5.68.2.3. Catches

5.68.2.3.1. Landings

During the last decade, the annual landings of striped mullet in GSA 05 have oscillated between 73-117 and 17-29 tons in the trawl and small-scale fishery, respectively (Fig. 5.68.2.3.1.1). Small-scale landings represent approximately 20% of the total landings.

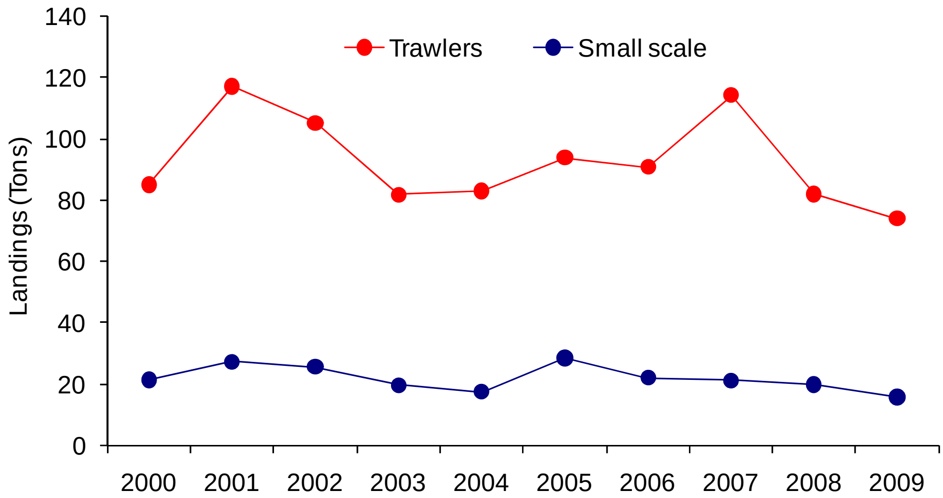


Fig. 5.68.2.3.1.1 Landings (in tons) from the trawl and small-scale fleets off Mallorca during the assessed period 2000-2009.

Tab. 5.68.2.3.1.1 Landings (in tons) as reported through the official 2010 DCF data call.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
MUR	5	ESP	OTB	DEMSP	40D50	130	101	100	117	108	132	98	91

5.68.2.3.2. Discards

The discards of striped red mullet from trawlers are negligible (Carbonell et al., 1997). Concerning the small-scale fleet twelve species were discarded at least in one occasion, and the discarded fraction in this fishery was 1.4% in number (Mas *et al.,* 2004). *M. surmuletus* were discarded in 19% of the fishing sets and made up the largest fraction of the discards (42.8% in number).

5.68.2.3.3. Fishing effort

Although there was a progressive diminution in the number of trawlers during the period 2000-2008, the total fishing effort remained rather constant because of the increase in vessel mean power (Fig. 5.68.2.3.3.1).

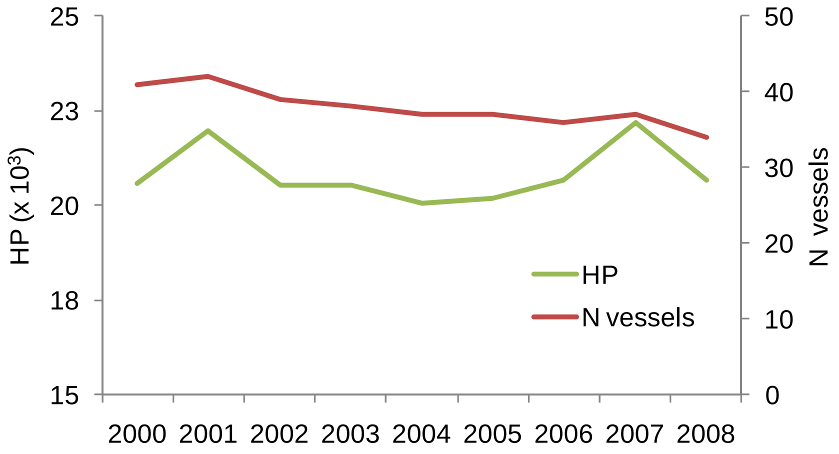


Fig. 5.68.2.3.3.1 Number of trawlers and total HP (mean HP x N of vessels) in Mallorca during 2000-2008.

5.68.3. *Scientific surveys*

No scientific survey data were separately presented in this assessment. However, surveys are used to calibrate the analytical assessment presented here.

5.68.4. *Assessment of historic stock parameters*

Striped red mullet was assessed in the STECF-SGMED-08-03 meeting, although by a mistake this assessment was not included in the final report. The assessment was subsequently presented to the GFCM hold in Izmir (Turkey) in 2008. In that case, the analyses performed were an XSA and a Y/R using the time series from 2000 to 2007. The recommendations to GFCM were not to increase the actual fishing effort since the resource was fully exploited, with the current Y/R close to the maximum and the current stock biomass being a 37% of the virgin stock.

5.68.4.1. Method 1: XSA

5.68.4.1.1. *Justification*

The length of the data series available (10 years, from 2000 to 2009) together with the availability of data from two different fleets (trawl and small-scale vessels) allowed the use of a VPA tuned with two sources (XSA), fishery data and surveys data. The software used was the Lowestoft suite (Darby and Flatman, 1994). A separable VPA (Pope and Shepherd, 1982) was also used as exploratory analysis.

5.68.4.1.2. *Input parameters*

Landings time series from 2000 to 2009 (Fig. 5.68.4.1.2.1) of the two fleets exploiting this species (trawl and small-scale fleet).

Length frequency distributions from monthly on port (small-scale) and on board (trawling) samplings developed during the entire time series (Fig. 5.68.4.1.2.1).

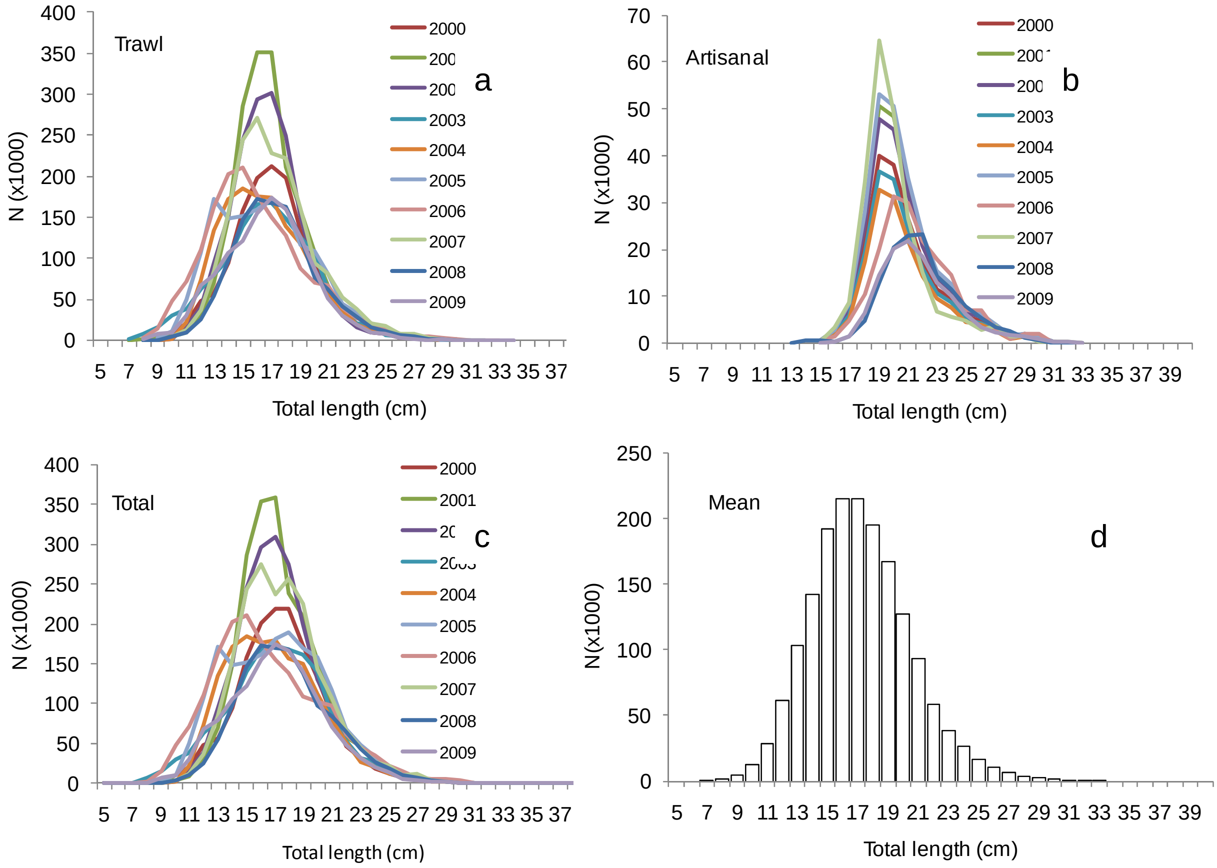


Fig. 5.68.4.1.2.1 Size frequency distributions of trawl fleet (a), artisanal fleet (b) and both fleets combined (c) by year; mean total distribution during the entire series 2000-2009 (d).

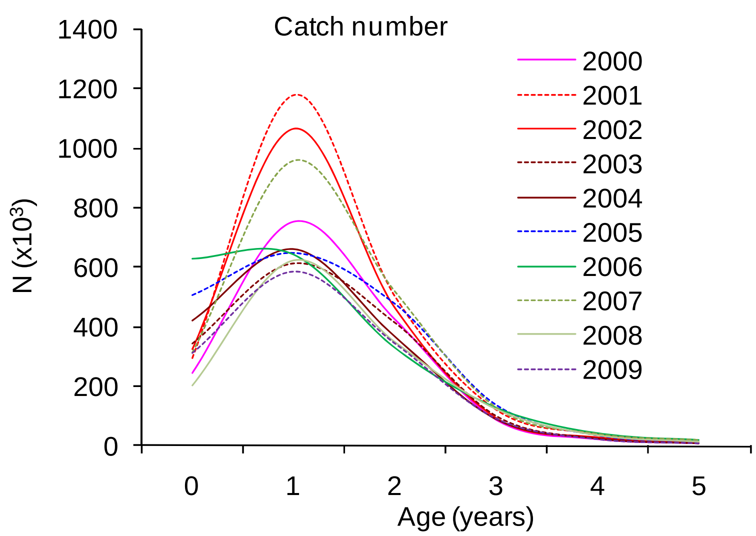


Fig. 5.68.4.1.2.2 Landings numbers at age, 2000-2009.

Tab. 5.68.4.1.2.1 Landings numbers at age (in thousands), 2000-2009.

AGE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	246	294	325	345	421	505	631	312	203	312
1	751	1180	1066	614	660	646	645	955	621	584
2	425	502	464	415	367	476	331	517	348	344
3	90	120	94	102	91	138	130	128	124	93
4	25	39	29	26	26	36	44	40	37	24
5	11	12	14	10	10	15	21	19	15	10
	1547	2147	1991	1511	1574	1814	1801	1971	1348	1366

Tab. 5.68.4.1.2.2 Stock and catch weights and at age (in kg), 2000-2009.

AGE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0.029	0.031	0.031	0.026	0.03	0.028	0.027	0.031	0.031	0.028
1	0.059	0.058	0.059	0.059	0.058	0.059	0.056	0.058	0.059	0.059
2	0.099	0.099	0.098	0.1	0.099	0.101	0.102	0.099	0.1	0.099
3	0.152	0.153	0.152	0.153	0.151	0.153	0.154	0.152	0.152	0.152
4	0.209	0.21	0.21	0.208	0.209	0.208	0.209	0.209	0.209	0.207
5	0.29	0.298	0.288	0.3	0.298	0.298	0.307	0.285	0.287	0.309

The biological parameters used for the assessment were the following: 1) growth parameters obtained from otolith readings carried out in the framework of the Spanish National Data Collection (L_{inf}= 40.05, K= 0.164, t_0= -1.883); 2) length-weight relationships obtained from the Spanish National Data Collection (a= 0.0084, b= 3.118); 3) natural mortality at age (Tab. 5.68.4.1.2.3) calculated using the PROBIOM spreadsheet (Abella et al. 1997); and 4) maturity at age (Tab. 5.68.4.1.2.4) obtained from the Spanish National Data Collection in GSA 05.

Tab. 5.68.4.1.2.3 Natural mortality (M) at age.

Age	0	1	2	3	4	5	Mean
M	1.33	0.65	0.41	0.34	0.31	0.29	0.56

Tab. 5.68.4.1.2.4 Maturity at age.

Age	0	1	2	3	4	5
Proportion of matures	0.15	0.39	0.79	0.95	1.00	1.00

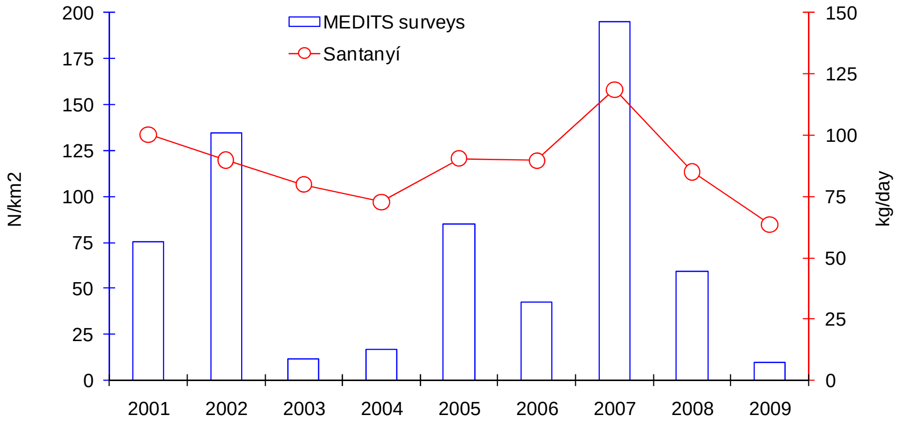


Fig. 5.68.4.1.2.3 Abundance indices from fishery (Santanyí) and surveys (MEDITS) used in the assessment.

Tab. 5.68.4.1.2.4 Time series of tuning indices at age as used in the XSA assessment.

Abundance indices MEDITS										
Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	166.5	231.1	243	245.4	283.9	404.4	534.8	290	119.2	232
1	450	825.6	766.1	409.5	404.4	437.1	484.4	850.3	394.9	308.1
2	187.7	255.7	235.8	209.7	171.7	217.7	185.9	345.1	189.7	134.1
3	32.5	55.1	39.6	45.1	40.4	58.3	61.1	95.6	48.6	20.8
4	7.2	16.5	10.3	8.6	9.9	12.3	19.6	28.7	11.1	4.8
5	2.1	2.3	4.6	2.2	2.9	3.3	9.6	10.6	2.3	0.6
Abundance indices fishery										
Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	-	197.3	92.5	13.3	118.7	36.7	55.9	414.5	7.5	8.5
1	-	967.2	1165.9	115.4	145.1	613.9	417.8	2369	221.2	102
2	-	162.7	506.6	36.8	48.3	396.3	139.4	498.4	214.8	21.1
3	-	31.2	97.3	11.6	10.9	72.8	41.2	90.6	137.3	14.3
4	-	5.9	23.9	2.6	1.8	7.8	4.3	16.1	28	-0.01
5	-	-0.01	-6.6	-0.01	-1.5	-5.5	-0.01	-0.01	-5.1	-0.01

5.68.4.1.3. Results

Terminal fishing mortality (Ft) was obtained from the catch curve, using the FLEDA package (Jardim & Azevedo 2004), and adjusted afterwards with a previous VPA followed by a Separable VPA. Different trials were done to obtain the best results from the Separable VPA changing both the reference age and the terminal selection value. The best fit was obtained with a reference age of 2 and a terminal selection value of 0.80. The figures below (Fig. 5.68.4.1.3.1) show the residuals and the selection at age (Sa) curve in the best fit. Residuals were always smaller than 1 (most of them <0.5) and did not show any tendency throughout the years. Finally, the vector of F by age, including the Ft, obtained with this Separable VPA was used as input parameters (Tab. 5.68.4.1.3.1).

Tab. 5.68.4.1.3.1 Fishing mortality (F) at age as determined by the separable VPA.

Age	0	1	2	3	4	5
F	0.092	0.470	0.817	0.778	0.617	0.654

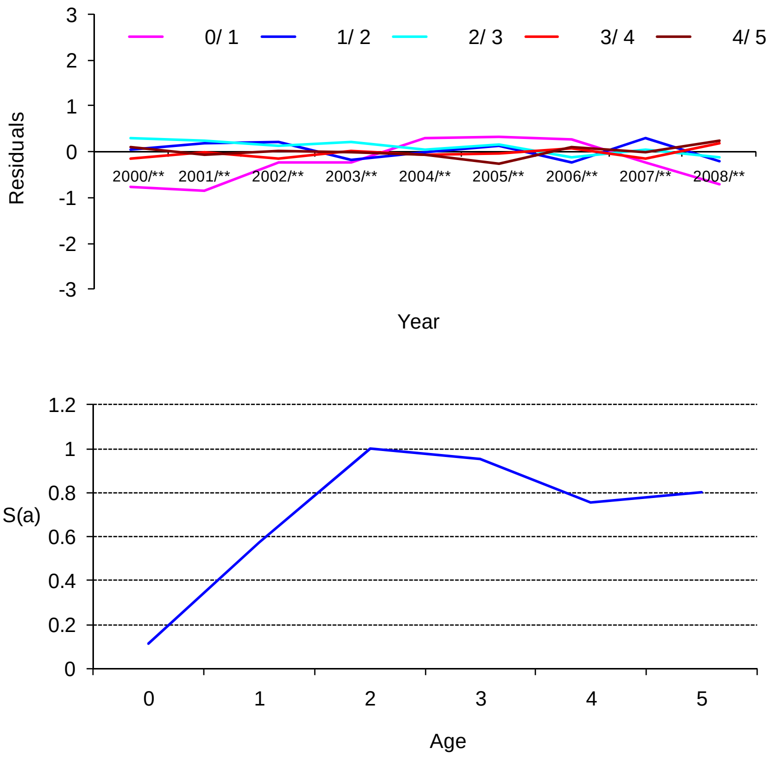


Fig. 5.68.4.1.3.1 Residuals and selection at age (Sa) curve from a Separable VPA.

XSA tuning were performed using abuncance indices from MEDITS surveys (N/km^2) developed during 2001–2009 around the Balearic Islands and CPUEs of daily landings from the trawling fleet of one port of Mallorca (Santanyí). The CPUE from this port, situated in the SE of the island, was chosen because its fleet works basically on the continental shelf, and thus it can be considered that its CPUE is a good indicator of the species abundance (as *Mullus surmuletus* inhabits mainly on the shelf). The landings of this port represented 12–30% of the total catch of Mallorca during the assessed period. Abundance indices from surveys were calculated considering different bathymetric strata. For tuning VPA, the values obtained in the stratum corresponding to the continental shelf (<100 m depth) were used because they best reflected the evolution of commercial landings.

XSA assumes constant catchability with time, which is fulfilled in our case as reflects the linear relationship observed in catch and effort data from both the trawl and small-scale fleet (Fig. 5.68.4.1.3.2).

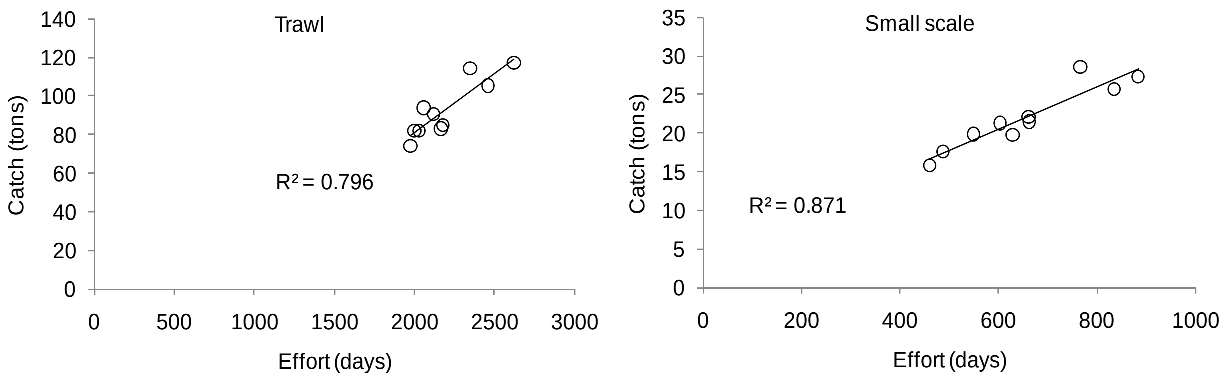


Fig. 5.68.4.1.3.2 Relationship between catch and fishing effort in the trawl and small-scale fleets from the Balearic Islands.

Several XSA trials were performed where the age at which catchability (q) is independent of stock size and the age at which q is independent of age were adjusted. Since results were similar in all these trials, the option finally used was considering q independent of stock size for ages <1 (recruits) and q independent of age for ages >= 4 because these values reflect very well the selection curve obtained in the Separable VPA (Fig. 5.68.4.1.3.1). Given that the residuals of the MEDITS data series for age 5 of the entire series and also for age 4 in 2009 were very high (Fig. 5.68.4.1.3.3), these ages were removed for the final XSA run. The vector of F by age and the residuals by year and age in the two tuning series (surveys and fishery) obtained in this last trial are shown below (Fig. 5.68.4.1.3.4). The regression statistics from the XSA diagnostics of the two data series showed that the fits were better for the fishery fleet than for the MEDITS surveys (Tab. 5.68.4.1.3.2).

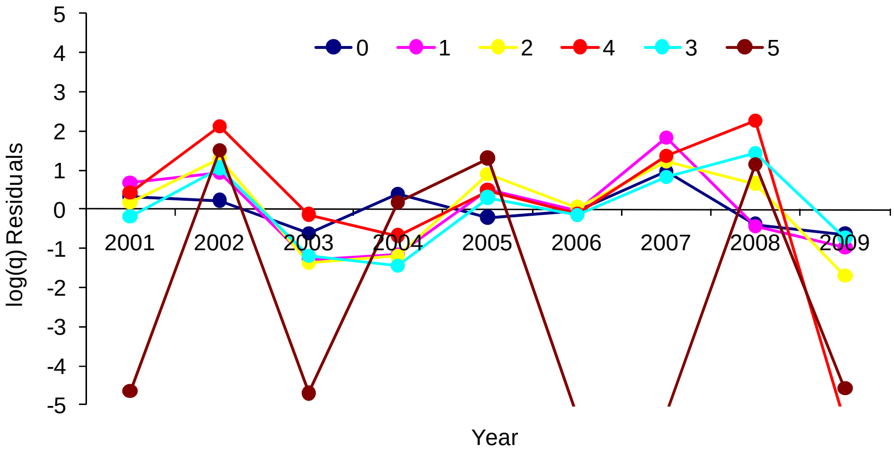


Fig. 5.68.4.1.3.3 Log (q) residuals of the MEDITS data series.

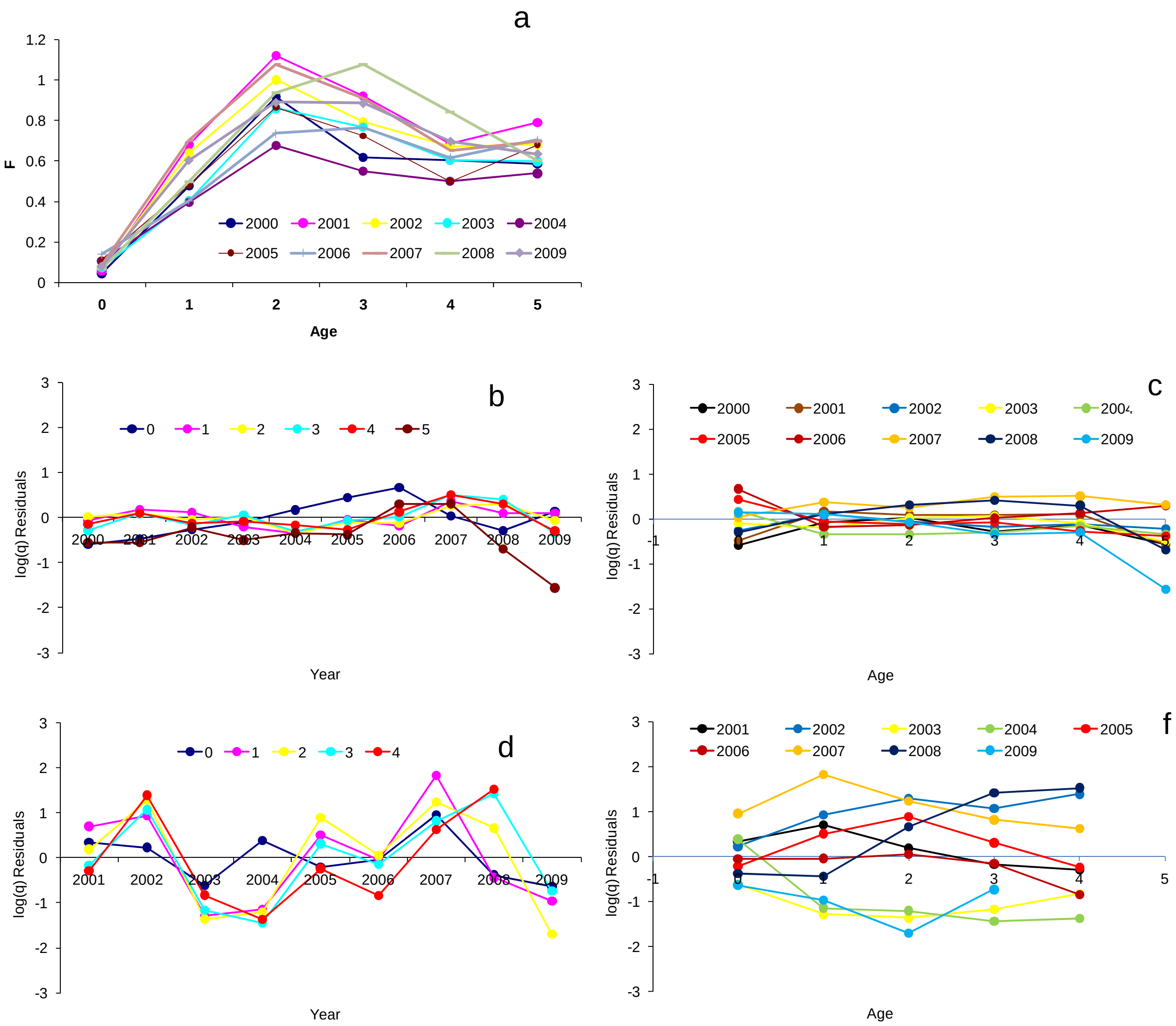


Fig. 5.68.4.1.3.4 Fishing mortality (F; a) and residuals by year and age from the two tuning data series (surveys: b, c; and fishery: d,f) obtained in the last XSA run.

Tab. 5.68.4.1.3.2 Regression statistics from the XSA diagnostics

Fleet: Santanyí 2000-09

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	eg s.e	Mean Log q
0	1.1	-0.124	9.49	0.16	10	0.42	-9.43

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	1.09	-0.187	7.67	0.37	10	0.25	-7.68
2	1.49	-0.586	7.75	0.16	10	0.3	-7.42
3	0.73	0.551	7.1	0.37	10	0.22	-7.7
4	0.68	1.28	6.88	0.68	10	0.17	-8.08
5	0.37	3.356	5.32	0.79	10	0.13	-8.5

Fleet: MEDITS Surveys
(N/km^2) 2001-2009

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
0	0.39	0.485	7.21	0.09	9	0.57	-4.59

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.29	1.204	5.96	0.31	9	0.3	-1.41
2	0.24	0.966	5.43	0.2	9	0.28	-1.32
3	0.91	0.043	1.74	0.03	9	0.98	-1.36
4	-3.51	-0.583	12.8	0	8	4	-2.06
5	0	0	0	0	0	0	0

The figures below (Fig. 5.68.4.1.3.5) show the main XSA results in terms of the fishing mortality by year and age, the stock biomass (SB) and spawning stock biomass (SSB) together with their relationship (SSB/SB), and the recruitment. Except the SSB (r= 0.777; p= 0.064), all other parameters showed a significant trend with time: both SB and the number of recruits showed a decreasing trend (r= 0.918; p= 0.002; r= 0.874; p= 0.010, respectively). In spite of this, the SSB/SB relationship showed an increasing trend with time (r=0.800; P= 0.046).

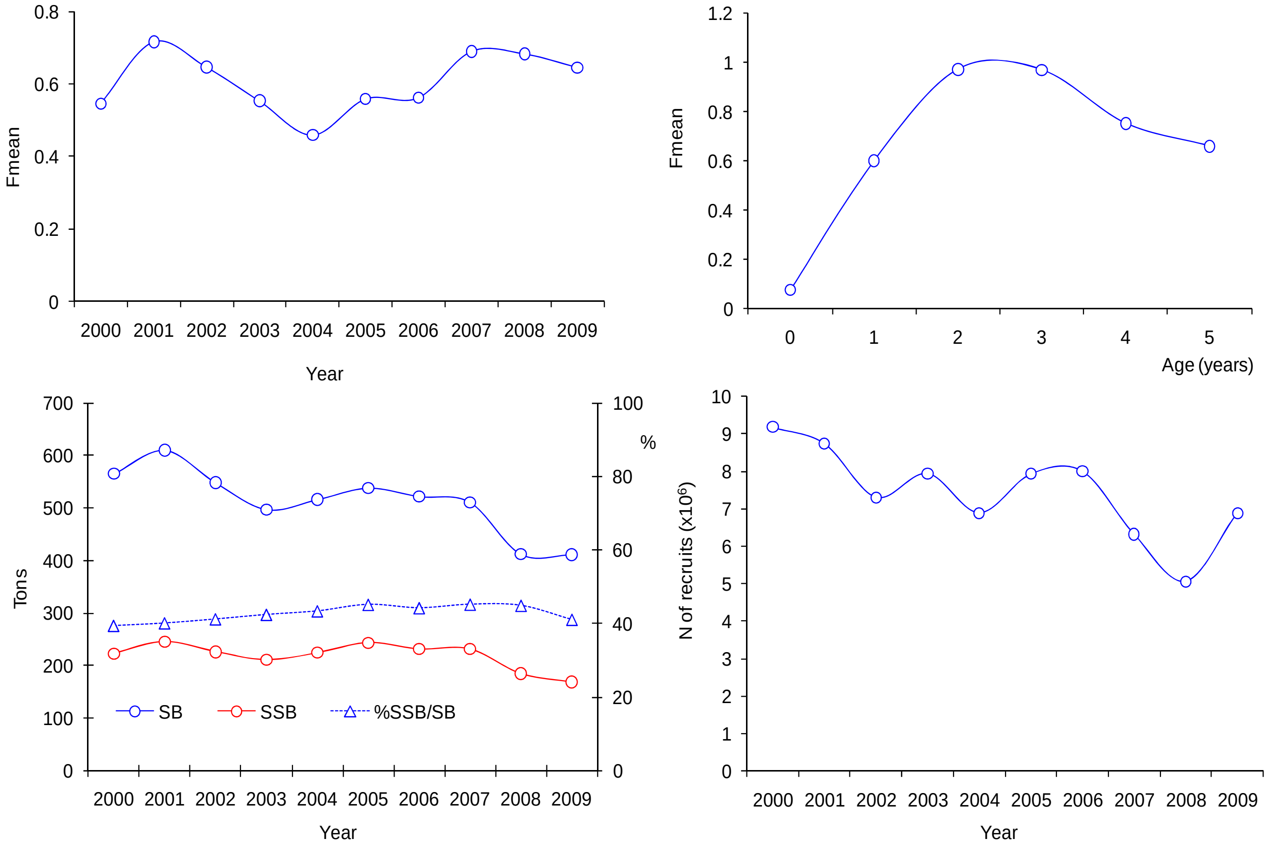


Fig. 5.68.4.1.3.5 Main assessment results: mean fishing mortality (F_{mean}) by year and age; stock biomass (SB), spawning stock biomass (SSB) and the percentage between both (%SSB/SB); and number of recruits through 2000-2009.

Tab. 5.68.4.1.3.3 Estimated fishing mortality at age, 2000-2009.

AGE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0.0451	0.057	0.0761	0.0743	0.1062	0.1108	0.1392	0.0848	0.0687	0.0777
1	0.4768	0.68	0.6417	0.4042	0.398	0.4816	0.4055	0.7005	0.4985	0.6054
2	0.9194	1.1196	0.9984	0.8606	0.6767	0.8703	0.7402	1.0828	0.9419	0.8922
3	0.6192	0.9303	0.7913	0.7639	0.5493	0.7225	0.7733	0.9181	1.0972	0.8937
4	0.6116	0.6903	0.6828	0.6002	0.4949	0.4994	0.6127	0.6622	0.8675	0.7297
5	0.6058	0.8157	0.6869	0.6175	0.5348	0.6689	0.7036	0.6868	0.6211	0.6739
FBAR 0- 5	0.5463	0.7155	0.6462	0.5535	0.46	0.5589	0.5624	0.6892	0.6825	0.6455

Tab. 5.68.4.1.3.4 Estimated stock size in numbers at age, 2000-2010.

AGE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	9178	8741	7307	7941	6891	7927	8000	6318	5054	6881	0
1	2674	3227	3038	2491	2712	2280	2610	2561	2135	1736	2342
2	863	911	897	878	913	1000	773	955	697	712	520
3	227	231	199	222	249	311	281	247	217	182	196
4	63	91	67	67	76	106	112	96	73	54	55
5	27	25	34	25	27	35	48	45	37	23	19

Tab. 5.68.4.1.3.5 Estimated stock parameters (recruits at age 0, stock weight, SSB, landings and mean F) obtained from the XSA summary table with SOP correction, 2000-2009.

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 0- 5
2000	9178	521	205	107	0.5183	0.9222	0.5463
2001	8741	560	225	144	0.6426	0.9172	0.7155
2002	7307	502	207	131	0.6321	0.9171	0.6462
2003	7941	456	194	102	0.5235	0.9184	0.5535
2004	6891	475	206	101	0.4885	0.9204	0.46
2005	7927	495	224	123	0.5475	0.9201	0.5589
2006	8000	481	213	113	0.5308	0.9214	0.5624
2007	6318	462	209	136	0.6486	0.9062	0.6892
2008	5054	386	173	102	0.587	0.9383	0.6825
2009	6881	372	153	90	0.5874	0.9047	0.6455

5.68.5. Long term prediction

5.68.5.1. Justification

Yield per recruit analysis was conducted based on the exploitation pattern resulting from the XSA model and population parameters.

5.68.5.2. Input parameters

Minimum and maximum ages for the analysis were 0 and 5 years, respectively. Stock weight at age and catch weight at age were estimated as mean values on a long term basis (2000-2009). Natural mortality by age was from PROBIOM (Abella *et al*., 1997) as recommended in the report of the SG-ECA/RST/MED-09-01. Fishing mortalities were estimated in a short term basis (F in 2009). Reference F was considered to be mean F for ages 1 to 5. Input parameters are shown in Tab. 5.68.5.2.1.

Tab. 5.68.5.2.1 Input parameters for the Y/R analysis.

Age group	Stock weight	Catch weight	Maturity	F	M
0	0.029	0.029	0.15	0.0777	1.00
1	0.058	0.058	0.39	0.6054	0.60
2	0.100	0.100	0.79	0.8922	0.40
3	0.152	0.152	0.95	0.8937	0.30
4	0.209	0.209	1.00	0.7297	0.30
5	0.296	0.296	1.00	0.6739	0.30

5.68.5.3. Results

Tab. 5.68.5.3.1 shows the reference fishing mortality (Fref), along with the reference points F0.1 and the Fmax. Fig. 5.68.5.3.1 shows the results of the yield per recruit analysis and the Y/R and SSB/R.

Tab. 5.68.5.3.1 Reference fishing mortality (F_{refe}) and the referent points $F_{0.1}$ and the F_{max}.

$F_{0.1}$	0.288
F_{max}	1.510
F_{ref}	0.759

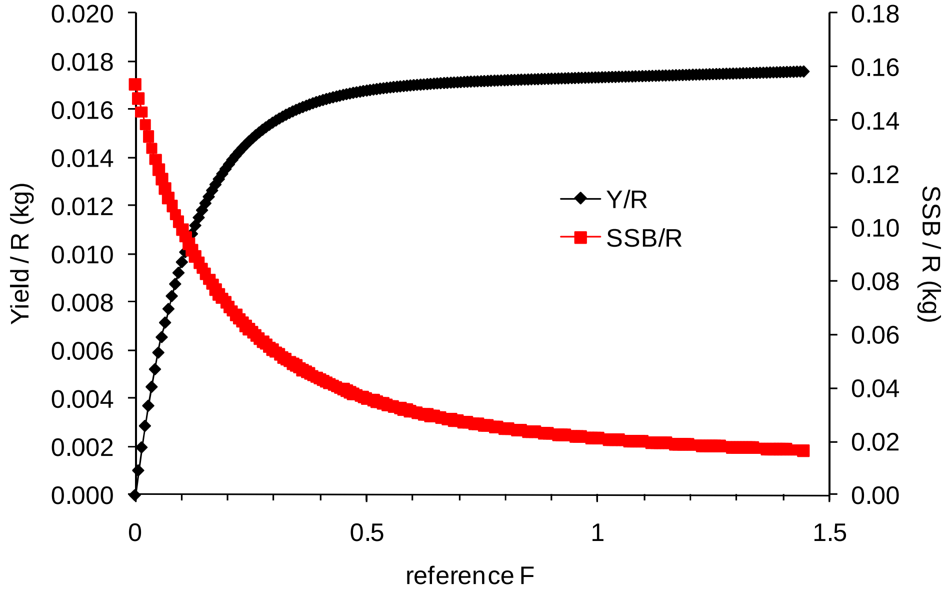


Fig. 5.68.5.3.1 Results of the yield per recruit analysis showing the Y/R and SSB/R.

5.68.6. Scientific advice

5.68.6.1. Short term considerations

5.68.6.1.1. State of the spawning stock size

SSB and stock biomass consistently declined over the time series since 2000 to the lowest value of the time series in 2009. In the absence of proposed and agreed precautionary reference points SGMED is unable to fully evaluate the state of the SSB.

5.68.6.1.2. State of recruitment

Recruitment showed a clear decreasing trend along the series; the number of recruits decreased from 9 to $5{\cdot}10^6$ between 2000 and 2008. Also the 2009 recruitment is estimated at a low level, consistently with the survey information.

5.68.6.1.3. State of exploitation

SGMED-10-02 recommend $F_{0.1}$=0.288 as limit management reference point consistent with high long term yield.

The F_{ref} (0.759) in 2009 is above the Y/R $F_{0.1}$ reference point (0.288), which indicates that striped red mullet in GSA 05 is overexploited.

SGMED-10-02 recommends the fishing mortality being reduced by means of a multi-annual management plan through fishing effort reductions and consistent catches being estimated. Such plan needs to consider the multi-species effects of the relevant fisheries.

5.69. Stock assessment of striped mullet in GSAs 22 and 23 combined

5.69.1. Stock identification and biological features

5.69.1.1. Stock Identification

The striped mullet stock is exploited by both the Greek and Turkish fishing fleets. Its spawning occurs from April to June, inclusive. Due to a lack of information about the structure of striped mullet population in the area, this stock was assumed to be confined within the GSA 22-23 boundaries.

5.69.1.2. Growth

No information was documented during SGMED-10-02.

5.69.1.3. Maturity

No information was documented during SGMED-10-02.

5.69.2. Fisheries

5.69.2.1. General description of fisheries

The bottom trawl fishery in Greece is a mixed fishery, operating from the beginning of October until the end of May, as a 4-month fishery closure (June-September) for bottom-trawlers is enforced by national legislation. The mesh size of the cod end of bottom trawls is 40 mm.

The gill nets are setting in the morning and are hauling the next day in depth from 80-300 m. The minimum mesh size used is about 48 to 64 mm. The fishery is carried out mainly during summer when bottom trawl fishery is closed.

5.69.2.2. Management regulations applicable in 2009 and 2010

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone 1.5 mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1st of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2008, the net should have been replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship-owner, by a diamond meshed net of 50 mm. So far, only a few boats have actually replaced their nets.

Several additional restrictions exist for bottom trawling in specific areas. For example in Amvrakikos Gulf, Pagassitikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1st of March till the end of November.

The operation of the bottom set nets is subject to the following main restrictions:
(1) the maximum total length of the trammel net is 6,000 m.

(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2,500 m.

5.69.2.3. Catches

5.69.2.3.1. Landings

No Greek landing data are available through DCF.

5.69.2.3.2. Discards

No discards data were reported to SGMED-10-02 through the DCF data call for Greece.

5.69.2.3.3. Fishing effort

Estimation of effort was based on interviews conducted with random sampling in 127 sampling stations (ports) in GSA 22-23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive, and the proportion of the year they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, fishing gear, and GSA. It should be noted that the estimated effort refers to the entire effort of each fleet segment. Tab. 5.69.2.3.3.1 lists the fishing effort reported to SGMED-10-02 through the DCR data call.

Tab. 5.69.2.3.3.1 Fishing effort in different units by fishing technique deployed in GSA 22+23, 2003-2008.

TYPE	AREA	COUNTRY	FT_LVL4	2002	2003	2004	2005	2006	2007	2008
DAYS	22	GRC	GTR		2078058	1908626	1993815	1914951		1374948
DAYS	22	GRC	LLS		20905	41155	41568	51501		302098
DAYS	22	GRC	OTB		52536	53381	56580	53367		51855
DAYS	22	GRC	PS		44481	43772	48211	42874		40029
DAYS	22	GRC	SB		36266	31987	33200	30098		25138
GT*DAYS	22	GRC	GTR		8567144	8034837	7939836	7571041		5309125
GT*DAYS	22	GRC	LLS		332005	577572	603419	780138		1244484
GT*DAYS	22	GRC	OTB		4927349	4972085	5553804	5556446		5355704
GT*DAYS	22	GRC	PS		1998124	1987556	2295466	2108039		1930332
GT*DAYS	22	GRC	SB		294896	269645	276265	257271		214985
KW*DAYS	22	GRC	GTR		68845607	70633794	70746878	66780942		50244080
KW*DAYS	22	GRC	LLS		1888201	4977272	2715667	3848302		7914684
KW*DAYS	22	GRC	OTB		15792715	15874762	17730748	16424382		16013057
KW*DAYS	22	GRC	PS		9389351	9140980	9656463	8992650		8233643
KW*DAYS	22	GRC	SB		2775797	2206815	2193550	2022231		1774864

5.69.3. Scientific surveys

5.69.3.1. MEDITS

5.69.3.1.1. Methods

Tables TA, TB, TC were provided according to the MEDITS protocol. The MEDITS survey was carried out in GSAs 22-23 every summer from 1994 to 2008, except in 2002, 2007 and 2009 because of administrative problems. In GSA 22 and 23, the number of stations was 98 in 1994 and gradually increased to 146 in 1996 and onwards. During the first two years (1994, 1995) the survey was conducted by two scientific teams from two institutes but with the same vessel. From 1996 three scientific teams were involved. During 1996 and 1997 two commercial vessels were used, and three vessels from 1998. Due to these changes in the survey design, caution is needed when investigating the trends of relevant indicators in the MEDITS time series, unless the data are properly standardised. More details on methodology and trends on selected indicators may be found in MEDITS (2007).

Based on the DCR data call, abundance and biomass indices were calculated. In GSAs 22 and 23 the following number of hauls was reported per depth stratum (Tab. 5.69.3.1.1.1).

Tab. 5.69.3.1.1.1. Number of hauls per year and depth stratum in GSAs 22 and 23, 1994-2008.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GSA22+23_010-050	10	10	11	10	13	12	13	13		13	13	14	14		13
GSA22+23_050-100	19	21	22	28	24	26	21	25		25	23	24	24		27
GSA22+23_100-200	19	26	38	36	36	33	38	35		36	43	41	41		40
GSA22+23_200-500	32	35	45	50	51	54	50	48		51	53	52	52		52
GSA22+23_500-800	18	13	19	22	22	21	20	17		17	17	17	17		17

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration.

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai) / A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution or a quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O’Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.69.3.1.2. Geographical distribution patterns

No analyses were conducted during SGMED-10-02.

5.69.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of striped mullet in GSAs 22 and 23 was derived from the international survey Medits. Fig. 5.69.3.1.3.1 displays the estimated trend in stripped mullet abundance and biomass in GSAs 22 and 23.

The estimated abundance increased until 1999 and remained low thereafter, while the biomass shows yearly fluctuations without any trends.

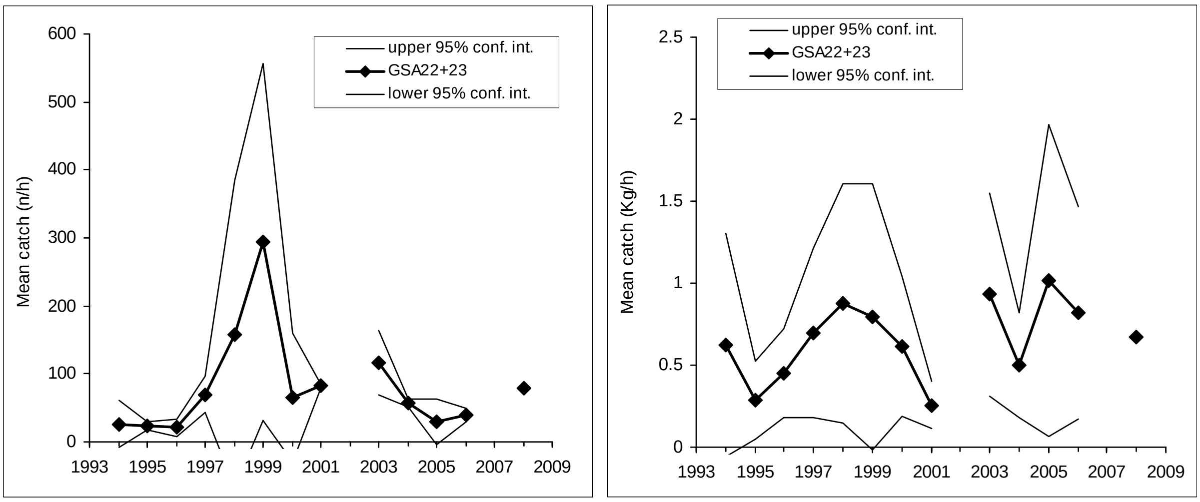


Fig. 5.69.3.1.3.1 Abundance and biomass indices of striped mullet in GSAs 22 and 23.

5.69.3.1.4. Trends in abundance by length or age

The following Fig. 5.69.3.1.4.1 and 2 display the stratified abundance indices of GSAs 22and 23 combined in 1994-2001 and 2003-2008.

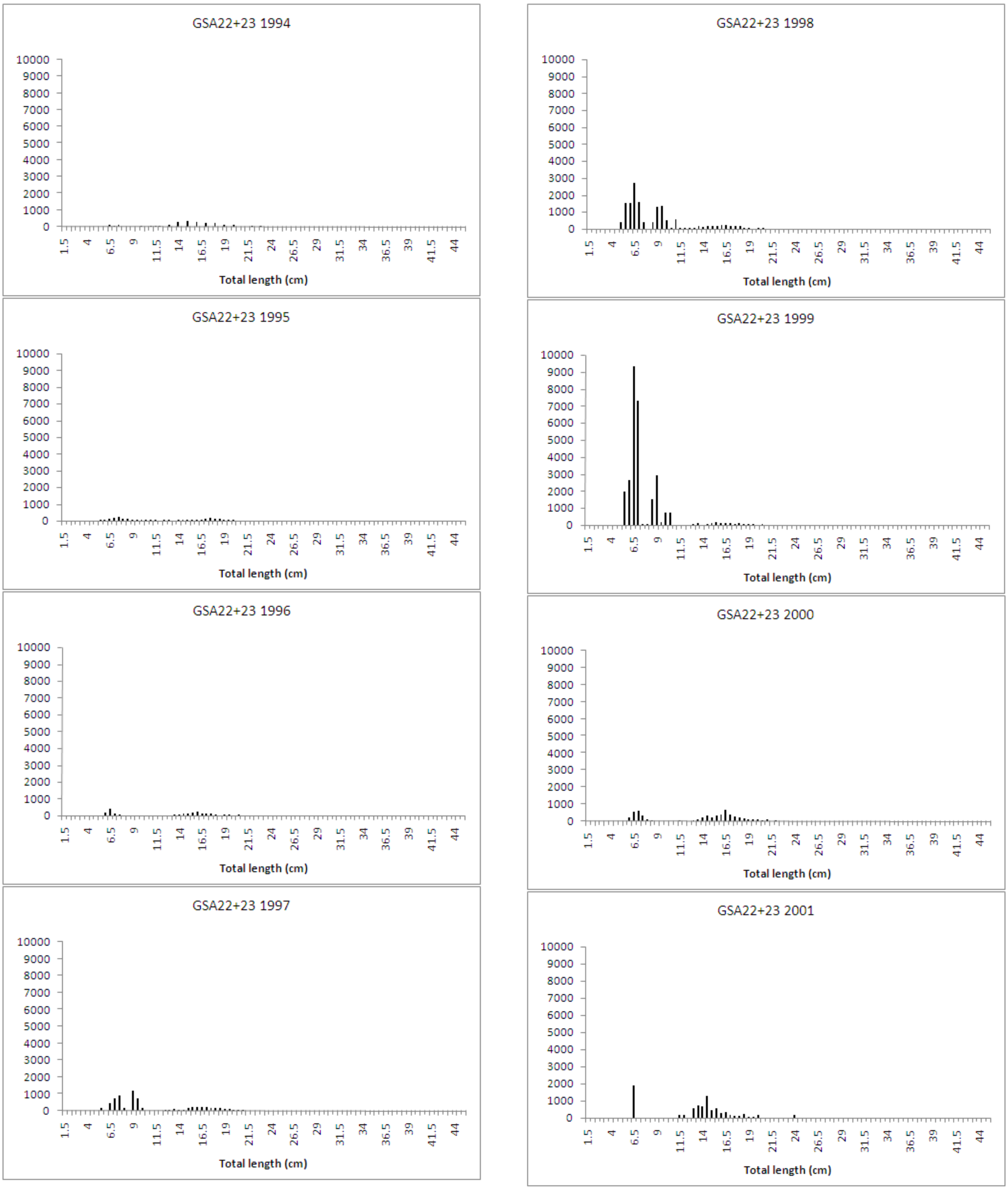


Fig. 5.69.3.1.4.1 Stratified abundance indices by size, 1994-2001.

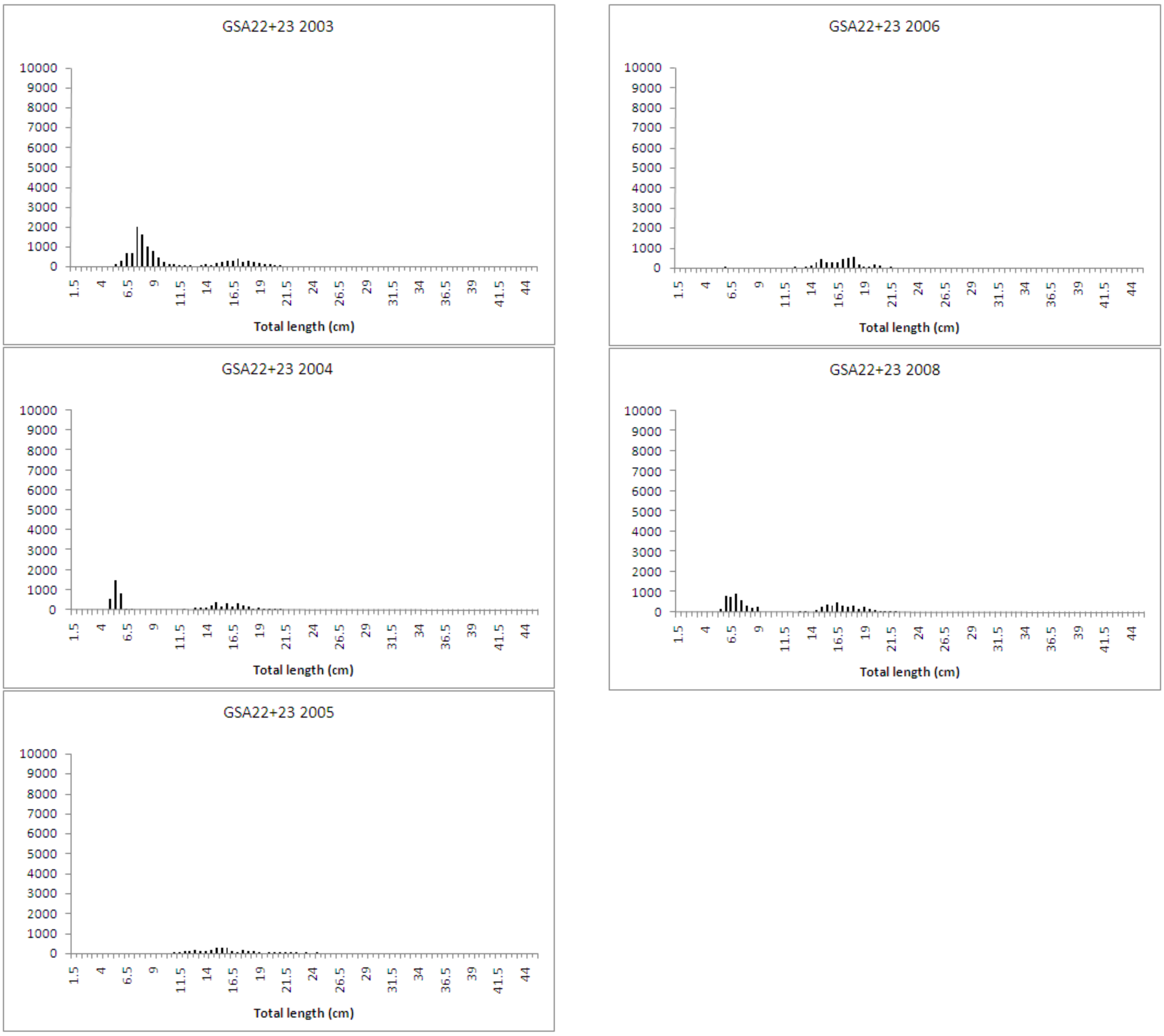


Fig. 5.69.3.1.4.2 Stratified abundance indices by size, 2003-2006 and 2008.

5.69.3.1.5. *Trends in growth*

No analyses were conducted during SGMED-10-02.

5.69.3.1.6. *Trends in maturity*

No analyses were conducted during SGMED-10-02.

5.69.4. Assessment of historic stock parameters

A new assessment is presented based on surplus production analysis. Age-based assessments could not be carried out due to lack of sufficient catch-at-age information. Attempts to analyse MEDITS survey data through the SURBA software failed as not proper model fitting was achieved.

5.69.4.1.Method 1: Surplus production model

5.69.4.1.1. Justification

The assessment estimates for the striped mullet (*Mullus surmuletus*) stock were based on the logistic surplus production model (Schaefer 1954) using a non-equilibrium approach which utilizes a time series of CPUE and landings data (Tserpes 2008).

The model is described below:

For a given *r* value the following approach has been followed:

1. Estimation of harvest rate for the beginning of the period

$$hr = \frac{F}{Z} \times (1 - e^{-Z})$$

2. Estimation of initial biomass fraction (i.e. B/k)

$$B_{fr} = 1 - \frac{hr}{r}$$

3. Estimation of a starting *k* value

$$k_{in} = \frac{C_{av} \times 4}{r}$$

(assumes that average catch is around to MSY).

4. Estimation of initial biomass

$$B_0 = B_{fr} \times k_{in}$$

5. Estimation of a starting *q* value

$$q_{in} = \frac{U_{av}}{B_0}$$

(U_{av}=mean abundance index)

6. Final estimates of model parameters *(k, q)* were obtained using a least squares criterion of fit assuming log-normally distributed residual errors between observed and expected abundance indices.

The equations used were:

$$B_t = B_{t+1} + rB_{t-1}(1 - \frac{B_{t-1}}{k}) - C_{t-1}$$

$$U_t = q \times B_t$$

$$\varepsilon_t = (\log U_t - \log \hat{U}_t)^2$$

$$U_t = (B_{t-1} + rB_{t-1}(1 - \frac{B_{t-1}}{k}) - C_{t-1}) \times q$$

The above steps have been repeated for a series of consecutive r values (range 0.30-0.99, interval 0.01). As the best model, was considered that providing the lowest error and its parameters were used to calculate population biomass time series as well as equilibrium MSY, B_{msy} and F_{msy} rates. Confidence intervals were estimated through bootstrapping. Model estimates were made by means of computer code developed in R-language.

5.69.4.1.2. Input parameters

The following data were used as input for the model:

Total Greek Aegean landings by year for the period 1990-2006 were extracted from National Statistical Service of Greece (NSSG) database and reconstructed to include small scale coastal fisheries catches based on the approach by Tsikliras *et al.* (2007) (Table 5.69.4.1.2.1). Landings of the eastern Aegean (Turkey) were extracted from the GFCM database.

Table 5.69.4.1.2.1.Striped mullet Aegean landings (in kg) for the period 1990-2006.

Year	Landings (kg)
1990	2393074
1991	2620789
1992	3278100
1993	2455548
1994	4171665
1995	3149295
1996	2871879
1997	2963074
1998	2262303
1999	2268237
2000	2418124
2001	2715494
2002	1918324
2003	2353854
2004	2030304
2005	2149870
2006	2499150

A yearly index of MEDITS CPUE series for the period 1996-2006 (excluding 2002 for which no data were available) based on data from the MEDITS project for GSA 22 (www.ifremer.fr/Medits_indices) (Table 5.69.4.1.2.2).

Table 5.69.4.1.2.2. Striped mullet in GSA 22. MEDITS CPUE index for 1996-2006.

Area	Year	CPUE index
22	1996	5.18
22	1997	7.15
22	1998	10.07
22	1999	8.94
22	2000	7.31
22	2001	3.01
22	2002	-
22	2003	9.49
22	2004	5.76
22	2005	8.80
22	2006	7.13

Exploitation rate at the beginning of the studied period based on the mortality estimates of the latest VPA assessment. Values of F and M for the beginning of the period were fixed to 0.80 and 0.42 respectively.

5.69.4.1.3. Results

The best fit was provided for r=0.75 (0.65-0.85) and k=16144 t (14350-17939). Based on the above estimates, equilibrium MSY was 3023 t (Figure 5.69.4.1.3.1) and the corresponding rates for fishing mortality and biomass were: F_{MSY}=r/2=0.38 and B_{MSY}=k/2=8072 t. Annual catches are below MSY since 1997, while stock biomass levels are increasing and exceed B_{MSY} (Figure 5.69.4.1.4.2). CPUE fluctuates with no trend (Figure 5.69.4.1.3.3).

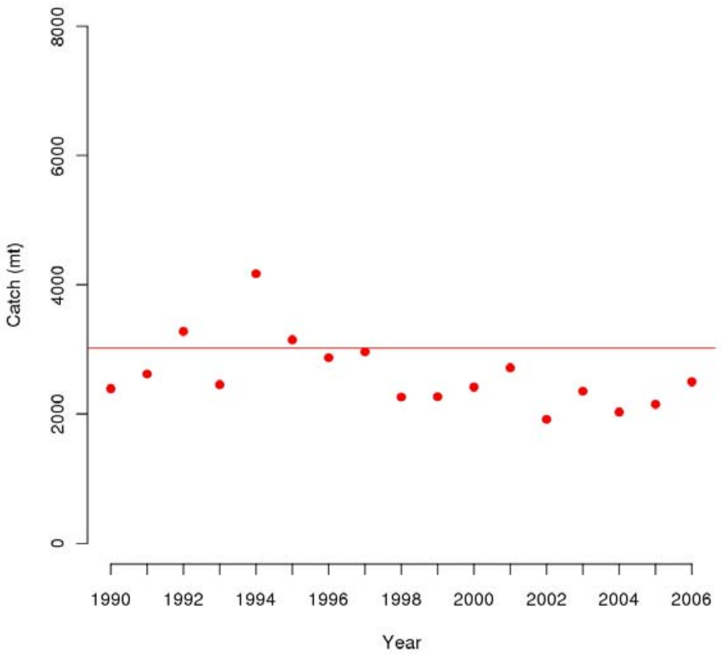


Figure 5.69.4.1.3.1. Striped mullet catch by year (red points) and MSY levels (red horizontal line).

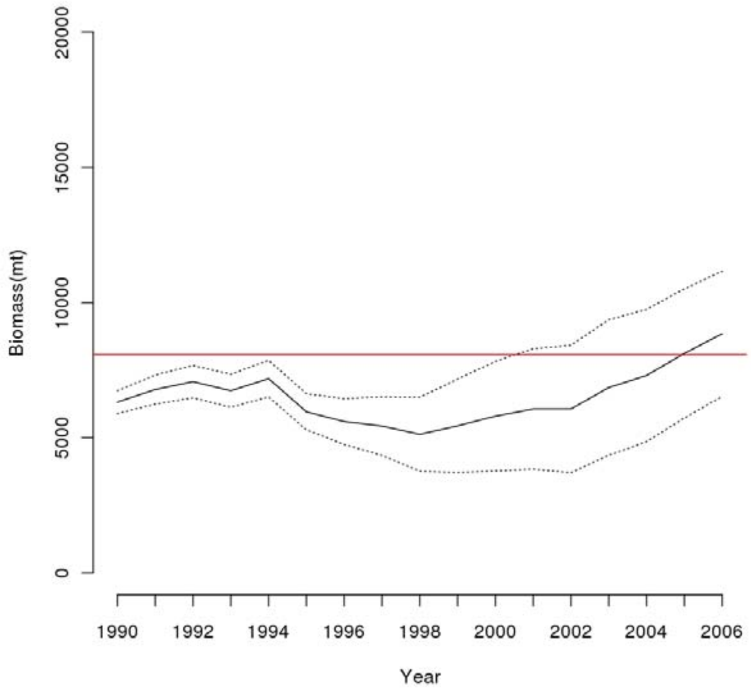


Figure 5.69.4.1.4.2. Striped mullet biomass (black solid line) by year and BMSY levels (red horizontal line).

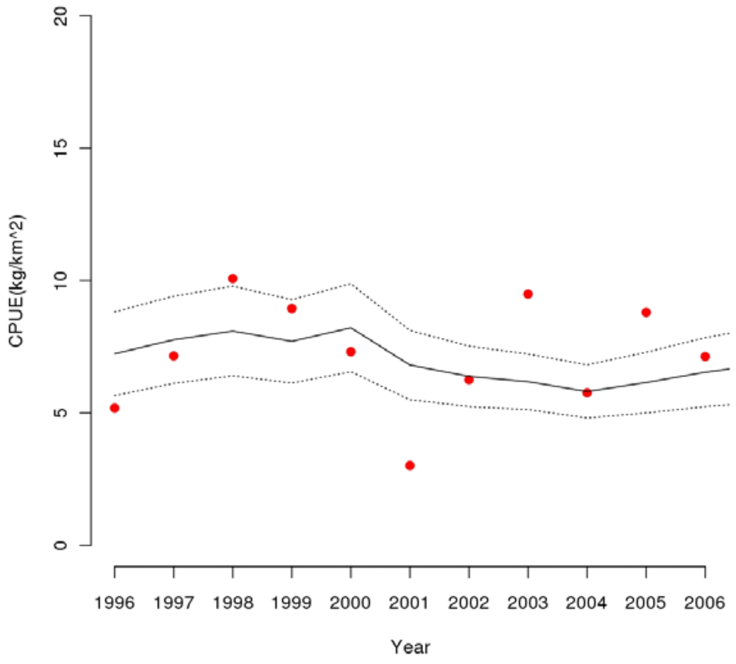


Figure 5.69.4.1.4.3. Striped mullet CPUE by year (red points) and model fitted line.

5.69.5. Long term prediction

5.69.5.1. Justification

A Y/R analysis was conducted using the Yield software.

5.69.5.2. Input parameters

Growth parameters

L_8	30
k	0.23
to	-1.1

Weight-length relationship

a (W-L)	0.03
b (W-L)	3.0

Natural mortality	0.45
Age at maturity	1
Age at first capture	0.9

5.69.5.3. Input parameters

Table 5.69.5.3.1 lists the reference points estimated from the yield per recruit analysis.

Tab. 5.69.5.3.1 Fisheries management reference values derived from yield per recruit analysis.

	Y(kg)/R
F_{msy}	0.69
$F_{0.1}$	0.33

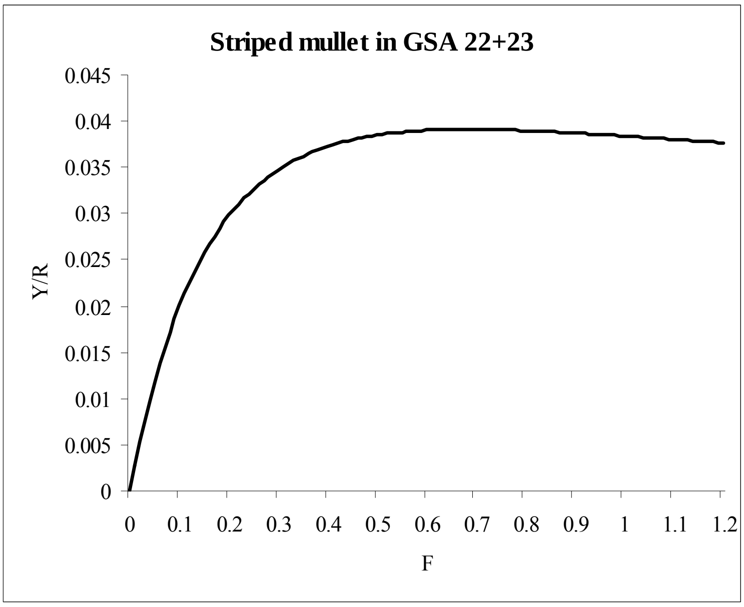


Fig. 5.69.5.3.1 YpR with increasing fishing mortality.

5.69.6. Data quality and availability

The lack of catch-at-age data did not allow the use of an age-based assessment that would provide a more detailed and robust information about the stock status. The quality of existing data did not seem to have any negative effect on the applied models. However, SGMED notes that due to lack of recent data, the assessment relies on data up to 2006. Thus, SGMED is not able to carry out a more recent assessment of the stock. Also, SGMED consider that the interruption of the survey time series and the lack of catch and weight at age data from the landings will preclude the assessment and management of striped mullet in GSA 22-23 in the next years.

5.69.7. Scientific advice

SGMED-10-02 considers all analyses presented to assess the status of striped mullet in GSAs 22 and 23 as preliminary and not suitable to provide sound scientific advice. Moreover, the lack of data from 2007 and onwards preclude a more recent assessment of the status of the stock.

5.69.7.1. Short term considerations

5.69.7.1.1. State of the spawning stock size

SGMED-10-02 is unable to provide any scientific advice of the state of the spawning stock given the preliminary state of the data and analyses.

5.69.7.1.2. State of recruitment

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.69.7.1.3. State of exploitation

SGMED-10-02 is unable to provide any scientific advice of the state of the recruitment given the preliminary state of the data and analyses.

5.70. Stock assessment of common pandora in GSA 09

5.70.1. Stock identification and biological features

5.70.1.1. Stock Identification

Common pandora (*Pagellus erythrinus*) is concentrated on the Mediterranean shelf. Even though the species can be found at depths over 200 m, it is mainly concentrated in the depth range 0-100 m. Studies of the bathymetric distribution and movements of *Pagellus erythrinus* in the Mediterranean show that is characterized by a spring–summer spawning season, spawners are highly concentrated at mid-shelf depths and nursery grounds are located in the vegetated shallows areas.

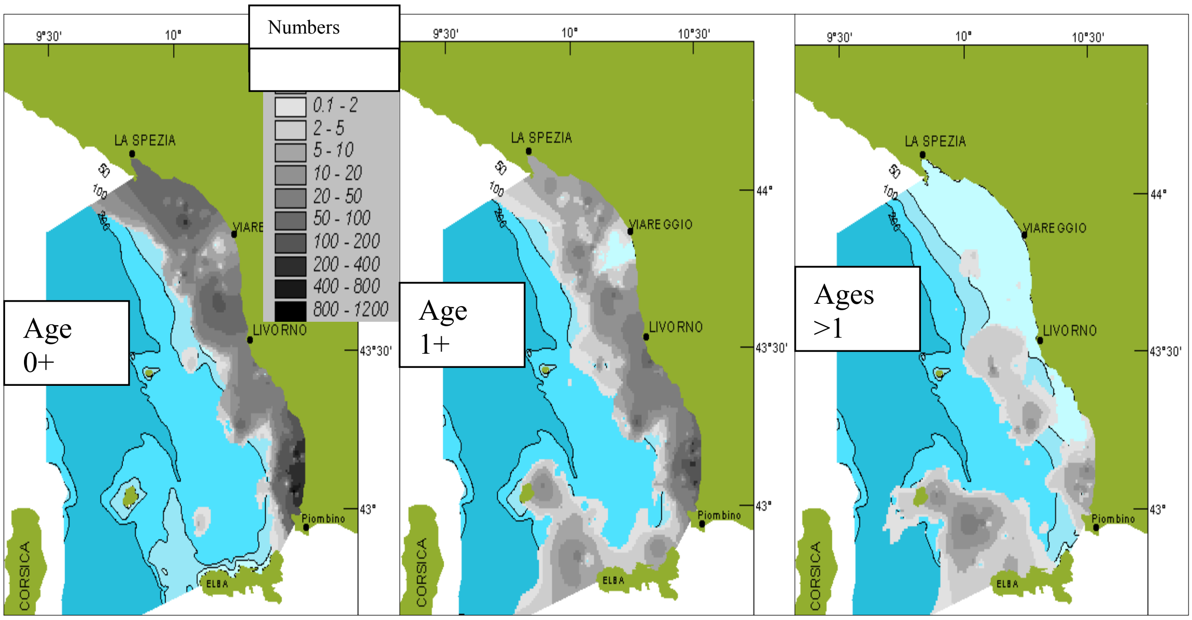


Fig. 5.70.1.1.1 Distribution of *Pagellus erythrinus* by year class in the Northern part of GSA 09.

There is no definition of unit stocks for the species available. The hypothesis of a single stock of common pandora in GSA 09, which includes waters belonging to two seas (Ligurian and Tyrrhenian) separated by the Elba Island with fleets that does not show any spatial overlapping, is unlikely. The inability to account for the spatial structure can lead to uncertainty in the definition of the status of the stocks, due to the possibility of local depletions, and therefore to a poor utilization of the potential productivity of the resources. Common pandora shows a positive relationship between individual size and size of the preys. Smaller individuals feed mainly on polychaetes, that are replaced by brachyuran crustaceans with growth. Fish and cephalopods are only an occasional component of the diet.

5.70.1.2. Growth

The species shows a moderate growth rate and may reach over 50 cm of total length.

Table 5.70.1.2.1. Common growth parameters and natural mortality rates considered representative for *P. erythrinus* in the GSA 09 utilized in the successive analyses.

L_∞		54.3
K		0.118
to		-1.12
L/W	a	0.0274
L/W	b	2.9556
A constant M value of 0.27 was used for Y/R analyses		

An estimate of M of 0.27 was used for yield-per-recruit computations and for deriving F from Z estimates.

5.70.1.3. Maturity

Spawning period is in the summer. It is a species mostly hermaphroditic protogynous reaching maturity at 1-2 years. Fecundity was estimated that is between 31,000-151,000 eggs between 16-31 cm.

5.70.2. Fisheries

5.70.2.1. General description of fisheries

Pagellus erythrinus is caught as a part of a species mix that constitutes the target of the trawlers operating near shore. The main commercial species in this mix in GSA 09 are *Squilla mantis, Sepia officinalis, Trigla lucerna, Merluccius merluccius, Mullus barbatus, Gobius niger*. Fishing effort has shown a moderate decline in the analyzed period. The species is mainly caught in late summer-beginnings of autumn. Size of full capture is about 8 cm. Catch is mainly composed by age 0 and 1 individuals while the older age classes are poorly represented. Catch rates remained almost stable along the study period. No dramatic changes occurred on effort allocation nor on other aspects of fishing behaviour in the analyzed years and thus a steady state of the stock abundance as suggested by trawl surveys data can be hypothesized. Even if catch within the coastal 3 miles is forbidden, illegal fishing do occur producing an unknown amount of fishing mortality on juveniles of the species. The main concentrations of older individuals are positioned at higher depths than juveniles and often over relatively hard bottoms and not trawlable areas. Set nets catch modest quantitatives of relatively large individuals. The exerted fishing pressure on this species on different zones of GSA 09 is quite variable as it is affected by the composition of that part of the fleet operating close to their respective ports, by the characteristics of the bottom that are potentially exploitable and are close to the ports and also by differences in the target species of the fisheries among fleets and zones.

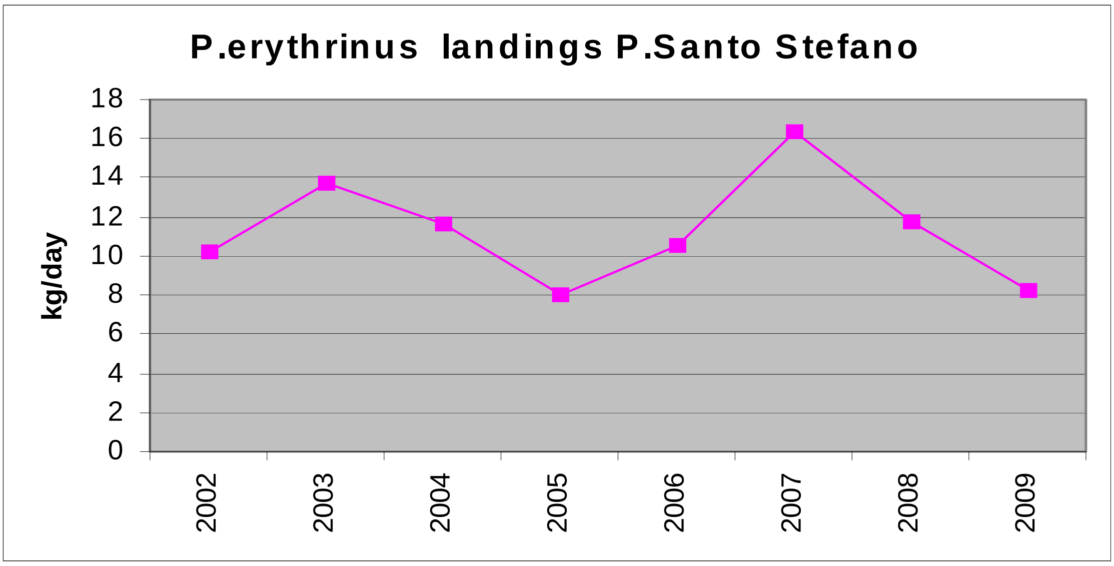
5.70.2.2. Management regulations applicable in 2009 and 2010

Fishing closure for trawling: A fishing ban of 45 days in late summer have been enforced certain years for some fleets in GSA 09. In 2008 it was compulsory for all the trawlers in the area and is expected this measure was repeated in 2009.
Minimum landing sizes: EC regulation 1967/2006 defined 15 cm TL as minimum legal landed size for common pandora.
Cod end mesh size of trawl nets: the 40 mm (stretched, diamond meshes) will continue to be utilized up to 30/05/2010. Since 1/6/2010, such cod end will be replaced by a 40 mm square meshes or alternatively by a net with a cod end of 50 mm (stretched) diamond meshes. It is not expected a noticeable increase in the size of entering to the fishery with the introduced changes because this size is only patially defined by the gear but also by the spatial distribution of juveniles.
Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

5.70.2.3.Catches

5.70.2.3.1. Landings

Landings data were reported to SGMED through the Data collection regulation. Landings from 2009 were not submitted by the Italian authorities. Annual landings, mostly from trawling, ranged from 413 tons in 2004 to 216 in 2008 tons in the last years. While the catch rates and landings increased in the two main ports located in the central portion of GSA 09, the landings in the Lazio region have shown, according to the official statistics a drastic drop, from 342 tons in 2004 to 175 in 2008. Discards of undersized individuals is large even though not easy to quantify. Part of the small sized individuals, even though potentially vulnerable to the gear, are mostly concentrated inside the 3 miles where trawling practices are forbidden.



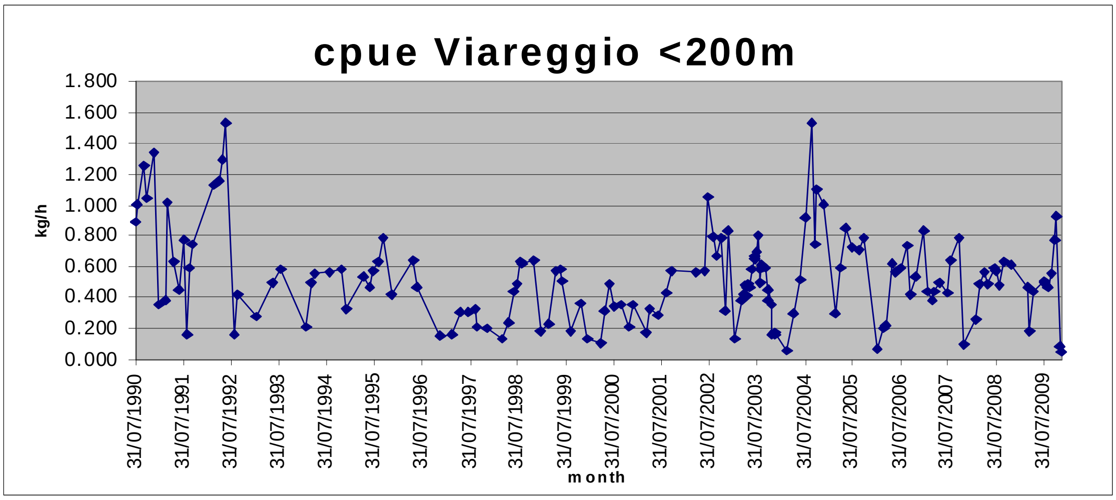


Fig. 5.70.2.3.1.1. Monthly catch rates with regular seasonal fluctuations (peaks in summer) in common pandora landings in two of the main ports of GSA 09 (Viareggio top, Porto santo Stefano bottom).

Tab. 5.70.2.31.1 Landings by fishing technique as reported through the official 2010 DCF data call. No 2009 data were submitted by the Italian authorities.

SPECIES	AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	2002	2003	2004	2005	2006	2007	2008	2009
PAC	9	ITA							1	1			
PAC	9	ITA	GNS	DEMSP				154	121	89	123	66	
PAC	9	ITA	GNS	SLPF					0			0	
PAC	9	ITA	GTR	DEMSP				76	73	71	19	47	
PAC	9	ITA	LLD	LPF					0	3			
PAC	9	ITA	LLS	DEMF					3	1	1		
PAC	9	ITA	OTB	DEMSP				79	31	34	40	95	
PAC	9	ITA	OTB	MDDWSP				103	164	91	87	8	
PAC	9	ITA	PS	SPF				0					
Sum								412	393	290	270	216	

5.70.2.3.2. Discards

No discard information on the species is reported

5.70.2.3.3. Fishing effort

Tab. 5.70.2.3.3.1 lists the effort by fishing technique deployed in GSA 09 as reported through the DCR data call. A minor decrease is observed for the main gear demersal otter trawl. It is however difficult to extract the real number of vessels that target common pandora from these figures. In the last 15 years, a general decrease in the size of the fishing fleets operating in the GSA 09 targeting demersal species was observed. The number of vessels targeting the species in question and the reduction in number along the time interval 1990-2007 is only known for some ports of the GSA. The reduction of number of vessels has been particularly important in Porto Santo Stefano fleet (about 50% of reduction) in the South and in Viareggio (about 30%) in the North. It is likely that this general reduction in numbers of vessels also apply for the fraction of the fleet that exerts its fishing effort on common pandora over all the GSA 09 fleets.

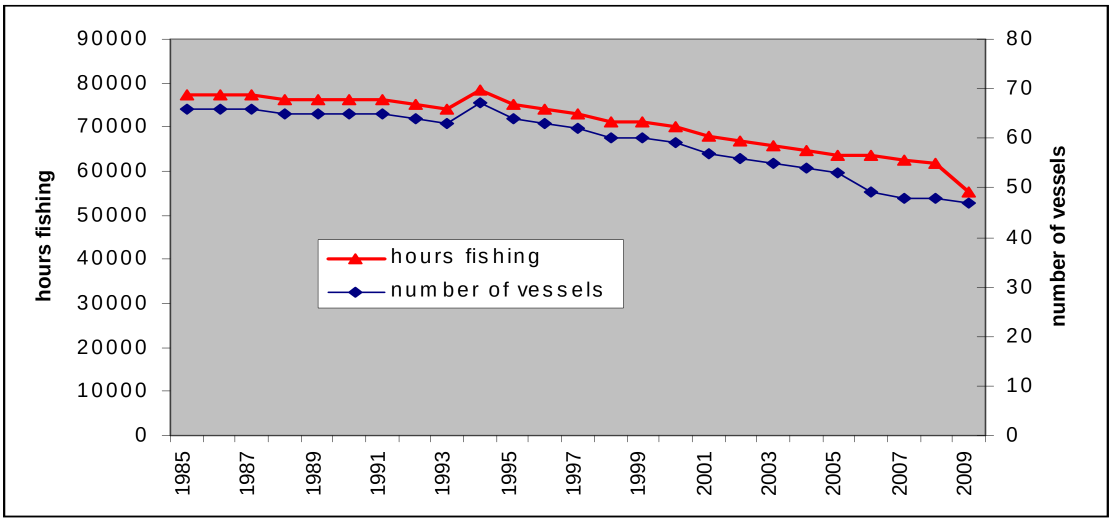


Fig. 5.70.2.3.3.1 Number of vessels and fishing activity in the port of Viareggio (1990-2008).

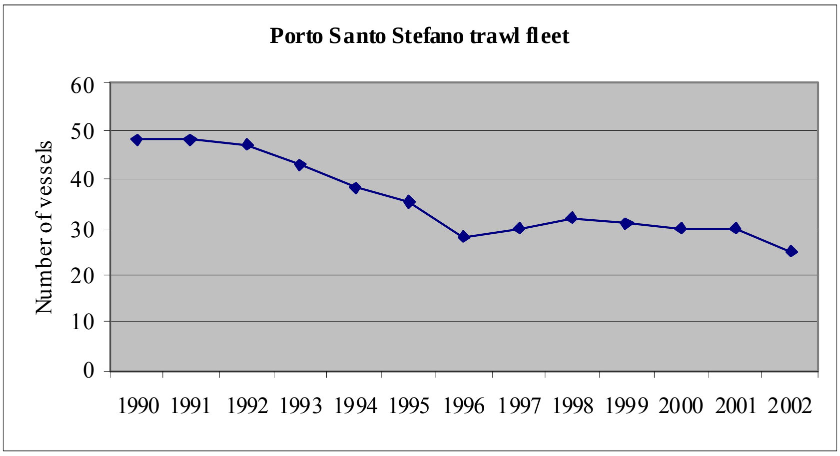


Fig. 5.70.2.3.3.2 Number of vessels in the port of Porto Santo Stefano (1990-2002).

Tab. 5.70.2.3.3.1 Effort trends (kW*days) by fishing technique in GSA 09 as reported through the official DCF data call in 2010. No data for 2009 were submitted by the Italian authorities. Data regards the whole fleets by fishing typology without any distinction regarding targets, season nor operations depth interval.

AREA	COUNTRY	FT_LVL4	FT_LVL5	FT_LVL6	VESSEL_LENGTH	2003	2004	2005	2006	2007	2008	2009
9	ITA				VL0006					296		
9	ITA				VL0612		31025	45782	71302	4865	12129	
9	ITA	DRB	MOL		VL1218		18652	20370	13504	29808	28266	
9	ITA	GNS	DEMSP		VL0006				14365	9687	7681	
9	ITA	GNS	DEMSP		VL0612		204925	219978	146971	201390	146006	
9	ITA	GNS	DEMSP		VL1218		100498	59006	49194	62666	67944	
9	ITA	GNS	SLPF		VL0612		4857				3707	
9	ITA	GTR	DEMSP		VL0006				1417	4451		
9	ITA	GTR	DEMSP		VL0612		75571	121141	100767	142363	43116	
9	ITA	GTR	DEMSP		VL1218		3222	19168	11102	14510	6610	
9	ITA	LLD	LPF		VL0612		6569	17394	3581	5904	25890	
9	ITA	LLD	LPF		VL1218		1611	4427	24956	5535	12094	
9	ITA	LLS	DEMF		VL0612		37454	75215	18823	4330		
9	ITA	LLS	DEMF		VL1218		3914	9998				
9	ITA	LTL	LPF		VL0006				3198	687		
9	ITA	OTB	DEMSP		VL0612		7282	6524	15126	21176	14595	
9	ITA	OTB	DEMSP		VL1218		118419	113284	77407	171295	221969	
9	ITA	OTB	DEMSP		VL1824		515183		69690	200680	478813	
9	ITA	OTB	DEMSP		VL2440		125282					
9	ITA	OTB	MDDWSP		VL1218		151739	183842	177083	158561	57869	
9	ITA	OTB	MDDWSP		VL1824		85625	737780	692516	404814	75728	
9	ITA	PS	SPF		VL0612			10014				
9	ITA	PS	SPF		VL1218			3703				
9	ITA	PS	SPF		VL1824		6526	6055				
9	ITA	SB-SV	DEMSP		VL0006				3780	3664	4506	
9	ITA	SB-SV	DEMSP		VL0612		127810	191056	133213	74903	62000	
9	ITA	SB-SV	DEMSP		VL1218		22438	10582	13566	2988	5196	

5.70.3. Scientific surveys

5.70.3.1. Medits

5.70.3.1.1. Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 09 the following number of hauls were reported per depth stratum (Tab. 5.70.3.1.1.1).

Tab. 5.70.3.1.1.1. Number of hauls per year and depth stratum in GSA 09, 1994-2009.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GSA09_010-050	19	18	18	18	19	18	18	18	13	13	13	14	13	13	13	14
GSA09_050-100	19	20	18	19	18	19	20	20	15	15	15	14	16	16	13	14
GSA09_100-200	35	35	36	35	35	35	34	34	26	27	26	27	25	26	28	27
GSA09_200-500	32	33	33	36	32	36	37	35	27	27	27	28	29	33	30	28
GSA09_500-800	31	30	31	28	30	28	27	29	24	22	21	20	20	17	18	20

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls considered valid were only used. Valid hauls include the cases of null catches of the species.

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

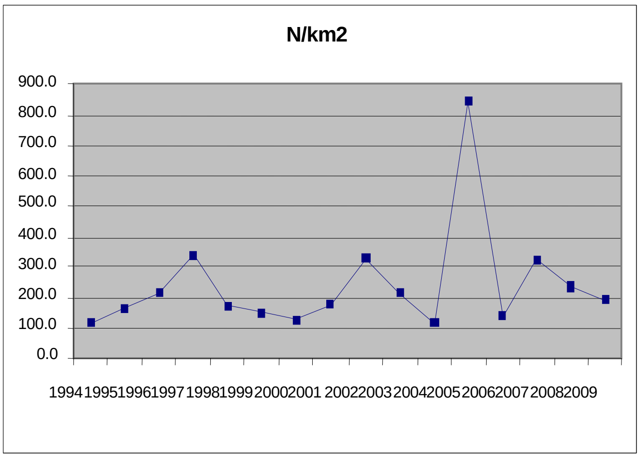
Length distributions represented an aggregation (sum) of all standardized length frequencies (sub-samples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

5.70.3.1.2. Geographical distribution patterns

The species is distributed all along the continental shelf of the GSA 09, with major abundance in the depth range 0-100 m. The species is highly concentrated along the coastal stripe 0-30 m with juveniles in very shallow waters. The major nursery areas are allocated in the northern portion of the GSA, northwards the Elba Island.

5.70.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of the common pandora in GSA 09 was derived from the international survey MEDITS. Figure 5.70.3.1.3.1 displays the estimated trends in abundance and biomass. The estimated abundance and biomass indices do not reveal any significant trend since 1994. However, the recent estimated biomass indices since 2005 appear to increase.



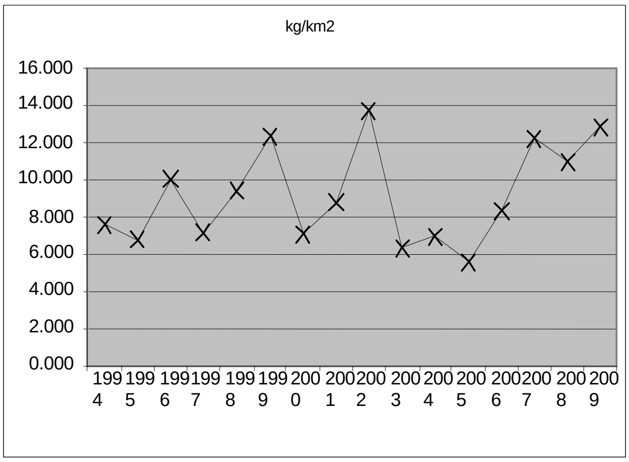


Fig. 7.20.3.1.3.1. Trends of abundance and biomass indices derived from MEDITS (1994-2009).

5.70.3.1.4. Trends in abundance by length or age

No analyses were conducted by SGMED-10-02.

5.70.3.1.5. Trends in growth

No analyses were conducted during SGMED-10-02.

5.70.3.1.6. Trends in maturity

No analyses were conducted during SGMED-10-02.

5.70.4. Assessment of historic stock parameters

5.70.4.1. Method 1: Model SEINE for estimation of Z

5.70.4.1.1. Justification

SEINE software (Survival Estimation in non-equilibrium situations) (Gedamke and Hoenig, 2006) was used for the estimation of Z, using weighted information of mean size of catch, size of full capture and growth parameters. In this study, the transitional behaviour of the mean length statistic is derived for use in nonequilibrium conditions. This new nonequilibrium estimator allows a change in mortality to be characterized reliably several years faster than would occur with the use of the Beverton–Holt estimator

Estimation of mortality rates in nonequilibrium situations can be accomplished by selecting the year of change and the values of Z1 and Z2 that cause predicted mean lengths from equation to best match a time series of estimated mean lengths. The method of maximum likelihood estimation is used.

5.70.4.1.2. Input parameters

Due to the lack of size structure of the commercial catch, MEDITS surveys were used for analyzing the changes in mean size for an estimation of Z with the mentioned approach, based on the Beverton & Holt well known equation, but without the assumption of equilibrium. It is assumed that they represent a good approximation of the size structure of the commercial catch, considering that the species is not a target and their catches split over a wide area where all the age classes are distributed. A critical size of first capture (full recruited individuals) of 8 cm was used.

5.70.4.1.3. Results and sensitivity analyses

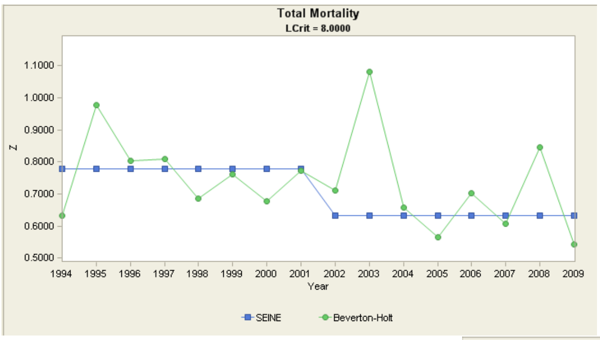
Survival Estimation in Non-Equilibrium Situations (SEINE) Version 1.3

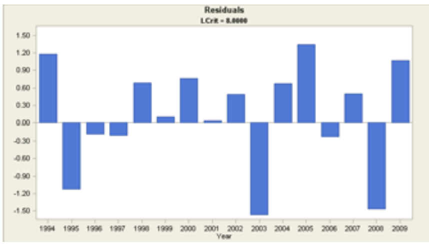
Date_of_Run: 21_Apr_2010
Time_of_Run: 09:37
Number of Breaks   = 1
First Year in Data   = 1994
Number of Years   = 16
Number of Parameters = 4
AIC   = 131.2488
Negative Log Likelihood = 61.6244
VB K   = 0.1180
VB Linf = 54.3000
L Crit   = 8.0000
Observed & Predicted Lengths

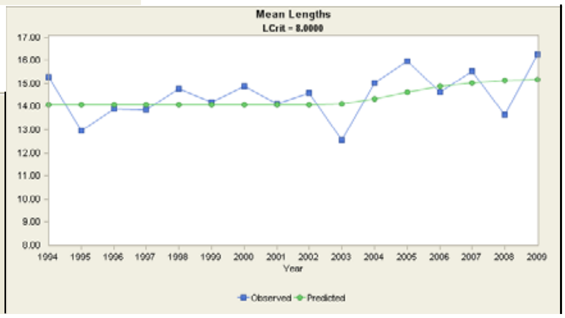
15.27000000	14.09943226	1.17056774
12.98000000	14.09943226	-1.11943226
13.92000000	14.09943226	-0.17943226
13.89000000	14.09943226	-0.20943226
14.79000000	14.09943226	0.69056774
14.20000000	14.09943226	0.10056774
14.87000000	14.09943226	0.77056774
14.14000000	14.09943226	0.04056774
14.59000000	14.09943226	0.49056774
12.55000000	14.11012134	-1.56012134
15.03000000	14.35316197	0.67683803
15.98000000	14.64497806	1.33502194
14.65000000	14.87235582	-0.22235582
15.53000000	15.02740661	0.50259339
13.66000000	15.12625739	-1.46625739
16.25000000	15.18670235	1.06329765

Total Mortality Estimates

0.77772271
0.63343090
Sigma = 11.38829052
Change Year Estimates







AIC	131.2488
Likelihood	61.6244

Parameter	Value	STD Deviation
Z 1	0.77772271	0.039267
Z 2	0.63343090	0.055421
Change Year 1	2002.813	0.855640
Sigma	11.38829052	2.013200

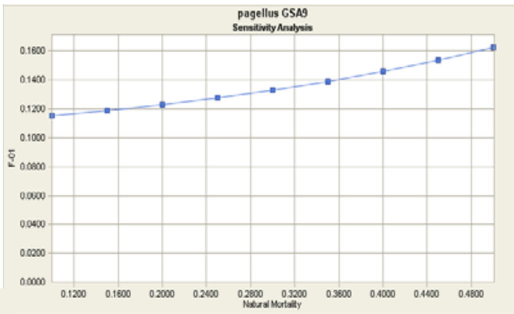
Fig. 5.70.4.1.3.1 Results of the seine model to estimate Z.

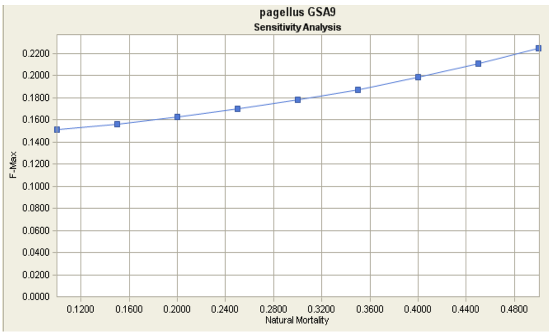
Considering the current F=0.36 (Z=0.63 and M=0.27), the species can be considered overexploited when compared with the values of the reference points $F_{0.1}$, F_{max} and $F_{40\%SSB}$.

Sensitivity analysis was performed in order to estimate the consequences of the choice of a constant value for M=0.27. With the rule of thumb of M≅1.65K based on the Beverton & Holt invariants (Jensen, 1996), a value of M=0.19 is obtained. The changes in the values of the reference points derived from the choice of one or the other value can be considered negligible.

Sensitivity Analysis Variable: Natural Mortality

Natural Mortality	F-01	F-Max	F at 40 % of MSP
0.1000	0.1151	0.1511	0.1318
0.1500	0.1187	0.1564	0.1354
0.2000	0.1228	0.1626	0.1395
0.2500	0.1275	0.1698	0.1442
0.3000	0.1329	0.1780	0.1495
0.3500	0.1390	0.1875	0.1556
0.4000	0.1460	0.1984	0.1623
0.4500	0.1539	0.2109	0.1699
0.5000	0.1628	0.2251	0.1783





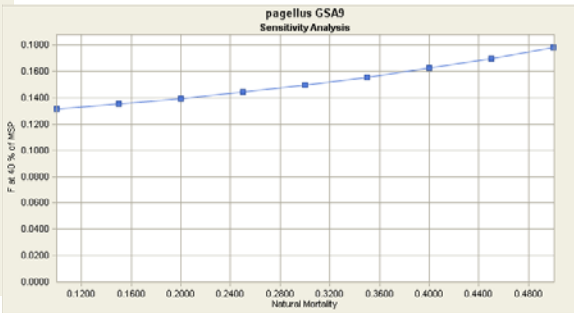
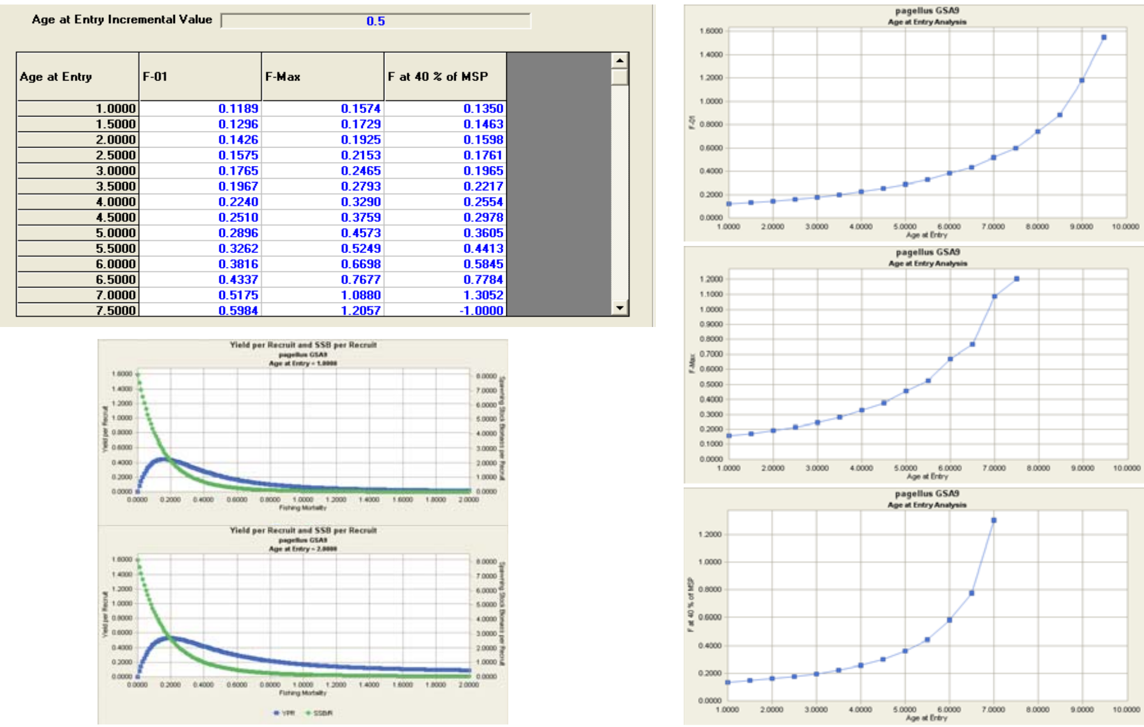


Fig. 5.70.4.1.3.2 Sensitivity analysis for M value related to the estimated value for the 3 chosen reference points.

There have been assessed the expected changes in the estimated values of $F_{0.1}$, F_{max} and $F_{40\%MSP}$ by changing the age of first capture. Results are shown in Fig. 5.70.4.1.3.3. Such values, as expected, are quite sensitive to the age of entry to the fisheries. For instance, by changing tc from age 1 to 2 should imply that the precautionary value of the proxy $F_{0.1}$ of the fishing mortality at F_{MSY} can be about 20% higher (from 0.12 to 0.14).



Age at Entry Incremental Value 0.5

Age at Entry	F-01	F-Max	F at 40 % of MSP
1.0000	0.1189	0.1574	0.1350
1.5000	0.1296	0.1729	0.1463
2.0000	0.1426	0.1925	0.1598
2.5000	0.1575	0.2153	0.1761
3.0000	0.1765	0.2465	0.1965
3.5000	0.1967	0.2793	0.2217
4.0000	0.2240	0.3290	0.2554
4.5000	0.2510	0.3759	0.2978
5.0000	0.2896	0.4573	0.3605
5.5000	0.3262	0.5249	0.4413
6.0000	0.3816	0.6698	0.5845
6.5000	0.4337	0.7677	0.7784
7.0000	0.5175	1.0880	1.3052
7.5000	0.5984	1.2057	-1.0000

Fig. 5.70.4.1.3.3 Changes in the values of the 3 chosen reference points with age of entry.

5.70.5. Long term prediction

5.70.5.1. Justification

A traditional Beverton & Holt Y/R analysis was performed with the “Yield” software.

5.70.5.2. Input parameters

The software does not allow using a vector of *M* and hence, in alternative, a constant value M=0.27 was used in input. The approach also assumes an asymptotic behavior of catchability over the size of first capture. The analysis was performed as a per-recruit basis, assuming recruitment constant with only a random fluctuation. The used growth and L/W parameters are those included in table 5.70.1.2.

5.70.5.3.Results

A value of F_{MAX} of 0.17 was estimated and of $F_{0.1}$ = 0.13 while the *F* rate at which the Spawning Biomass is expected to be reduced to 40% of the pristine Biomass ($F_{30\%SSB}$) was estimated as 0.14.

Relative per recruit estimated values of *Y* and *SSB* are shown in Fig 5.70.5.3.1.

Fig 5.70.5.3.1. Results of the Y/R analysis.

5.70.6. Scientific advice

5.70.6.1. Short term considerations

5.70.6.1.1. State of the spawning stock size

In the absence of proposed and agreed precautionary management reference points SGMED-10-02 is unable to fully evaluate the state of the SSB. The index of stock abundance from MEDITS survey shows high variability throughout the time series, but no statistical significant trend is observed.

5.70.6.1.2. State of recruitment

Recruitment shows no particular trend since 1994 and 2009, with a peak in 2005. The analysed data are believed to represents an underestimate of the numbers per km^2 because many juveniles are concentrated in very shallow waters poorly covered by the surveys.

5.70.6.1.3. State of exploitation

SGMED-10-02 proposed $F_{0.1}$=0.13 as limit management reference point of exploitation consistent with high long term yields. The stock can be considered overexploited. In relation to historic values, the abundance of the species is stable as demonstrated by the analysis of commercial LPUE's in the landings in the main ports of the area and from trawl surveys abundance indices. Available data is limited and do not allow a more detailed and precise assessment of the stock status.

SGMED-10-02 concludes that the common pandora stock in GSA 09 is overfished and a reduction of *F* of about 50% is required. This will likely drive the stock biomass close to the B_{MSY} level.

6. REFERENCES

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7. APPENDIX 1. SGMED OVERALL TERMS OF REFERENCE

The European Community is expected to establish long-term management plans (LTMP) for relevant Mediterranean demersal and small pelagic fisheries based on precautionary approach and adaptive management in taking measures designed to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine eco-systems.

The plans shall include conservation reference points such as targets against which measuring the recovery to or the maintenance of stocks within safe biological limits for fisheries exploiting stocks at/or within safe biological limits (e.g. population size and/or long-term yields and/or fishing mortality rate and/or stability of catches). The management plans shall be drawn up on the basis of the precautionary approach to fisheries management and take account of limit reference points as identified by scientists. The quantitative scientific assessment should provide sufficiently precise and accurate biological and economic indicators and reference points to allow also for an adaptive management of fisheries.

Stating clearly how stocks and fisheries will be assessed and how decision will be taken is fundamental for proper and effective implementation of management plans as well as for transparency and consultations with stakeholders.

Demersal and small pelagic stocks and fisheries in the Mediterranean are evaluated both at national and GFCM level; however these evaluations are often not recurring, are spatially restricted to only some GFCM geographical sub-areas (see attached reference map), covering only partially the overall spatial range where Community fishing fleets and stocks are distributed, and address only few stocks out of several that may be exploited in the same fisheries. Limited attention is also given to technical interactions between different fishing gears exploiting the same stocks.

A limited, although fundamental, scientific contribution of EU fishery scientists to the GFCM assessment process is increasingly affecting the capacity of this regional fisheries management organization to identify harvesting strategies and control rules and to adopt precautionary and adaptive fisheries management measures based on scientific advice.

Anyhow, GFCM and most of the riparian countries consider that management measures to control the exploitation rate and fishing effort, complemented by technical measures, are the most adequate approach for multi-species and multiple-gears Mediterranean fisheries.

Nevertheless, provided that scientific advice underlines to do so, also output measures may be conceivable to manage fisheries particularly for both small pelagic and benthic fish stocks.

Coherence and certain level of harmonization between Community and multilateral framework measures are advisable for effective conservation measures and to enhance responsible management supported by all concerned Parties and stakeholders in the Mediterranean.

STECF can play an important role in focusing greater contributions of European scientists towards stocks and fisheries assessment, in identifying a common scientific framework regarding specific analyses to advise on Community plans and to be then channeled into or completed by the GFCM working groups[1].

STECF was requested at its November plenary session to set up an operational work-programme for 2008, beginning in the 1st quarter of 2008, with a view to update the status of the main demersal stocks and evaluate the exploitation levels with respect to their biological and economic production potentials and the sustainability of the stock by using both trawl surveys and commercial catch/landing data as collected through the Community Data Collection regulation N° 1543/2000 as well as other scientific information collected at national level.

[1] STECF is requested to take into account the GFCM stock assessment forms as available at the web site http://www.gfcm.org/fishery/nems/36406/en

Within this work-programme STECF is also requested to provide its advice on the status of the main small pelagic stocks and to evaluate the exploitation levels with respect to their biological and economic production potentials and the sustainability of the stock by using both echo and/or DEPM surveys and commercial catch/landing data as collected through the Community Data Collection regulation N° 1543/2000 as well as other scientific information collected at national level.

STECF should take into consideration the data that Member States have been collecting on a regular basis both via monitoring fishing activities and carrying out direct surveys[2]. STECF, in replying at the following terms of reference, should also take into consideration chapter 7 of the 26th STECF Plenary session of 5-9 November 2007[3], as well as the report of the STECF working group on balance between fishing capacity and fishing opportunities[4].

STECF shall contribute to identify and setup an advisory framework regarding low risk adaptive management by identifying and using appropriate risk assessment methods in order to understand where we stand with respect to sustainable exploitation of ecologically and economically important stocks and what additional management actions need to be taken.

On the basis of the STECF advice the Commission will launch official data calls to EU Member States requesting submission of data collected under the Community Data Collection regulation N° 1543/2000.

STECF is requested in particular:

- to advice whether the data availability may allow the development of a precautionary conceptual framework within which develop specific harvesting strategies and decision control rules for an adaptive management of demersal and small pelagic fisheries in the Mediterranean;

- to set up a conceptual, methodological and operational assessment framework which will allow STECF to carry out in a standardized way both stocks assessment analyses and detailed reviews of assessments done by other scientific bodies in the Mediterranean. The selected assessment methods shall allow estimating indicators for measuring the current status of demersal and small pelagic fisheries and stocks, the sustainability of the exploitation and to measure progress towards higher fishing productivity (MSY or other proxy) with respect to precautionary technical/biological reference points relating to MSY or other yield-based reference points, to low risk of stock collapse and to maintaining the reproductive capacity of the stocks;

- to set up a conceptual, methodological and operational assessment framework which will allow STECF to identify economic indicators and reference points compatible with economic profitability of the main fisheries while ensuring sustainable exploitation of the stocks in the Mediterranean;

- to indicate whether age/length-based VPA or statistical catch-at –age/length methods are adequate modelling tools to estimate precautionary indicators and reference points measuring the current status and future development of multispecies/multigears Mediterranean fisheries. STECF shall also provide a conceptual and operational framework to use, if advisable, these methods for demersal and small pelagic Mediterranean fisheries;

- to identify adequate empirical modelling approaches that are adequate to estimate precautionary indicators and reference points measuring the current status and future development of multispecies/multigears Mediterranean fisheries. STECF shall also provide a conceptual and operational framework to use, if advisable, these methods for demersal and small pelagic Mediterranean fisheries;

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[2] Council Regulation (EC) No **1343/2007** of 13 November 2007 amending Regulation (EC) No 1543/2000 establishing a Community framework for the collection and management of the data needed to conduct the common fisheries policy

Commission Regulation (EC) No **1581/2004** of 27 August 2004 amending Regulation (EC) No 1639/2001 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000

[3] http://stecf.jrc.ec.europa.eu/38

[4] Report of the STECF Working Group on The Balance between Capacity and Exploitation SGRST-SGECA-07-05 Working group convened in the margin of SGECA-SGRST-SGECA-07-02 (Review of Scientific advice II), 22-26th Oct 2007. Evaluated and endorsed at the November plenary session.

- to identify the decision-making support modelling tools that are adequate for the Mediterranean fisheries and that will produce outputs that support sustainable use of fishery resources recognizing the need for a precautionary framework in the face of uncertainty and that may allow to provide projections of alternative scenarios for short-medium and long term management guidance;

- to provide either a qualitative or quantitative understanding of the level of precision and accuracy attached to the estimation of indicators and reference points through the different modelling tools;

- to identify which decision-making support modelling tools may help in setting up stock-size dependent harvesting strategies and respective decision control rules;

- to provide information on the data and standardised format needed for each of the decision-making support modelling tool which will be used to launch official data calls under the DCR n° 1543/2000. STECF should also indicate criteria to ensure quality cross- checks of the data received upon the calls.

8. APPENDIX 2. SGMED-10-02 PARTICIPANTS LIST

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9. APPENDIX 3. FLEET SEGMENTATION IN THE MEDITERRANEAN SEA

(copied from SGMED-08-01 report).

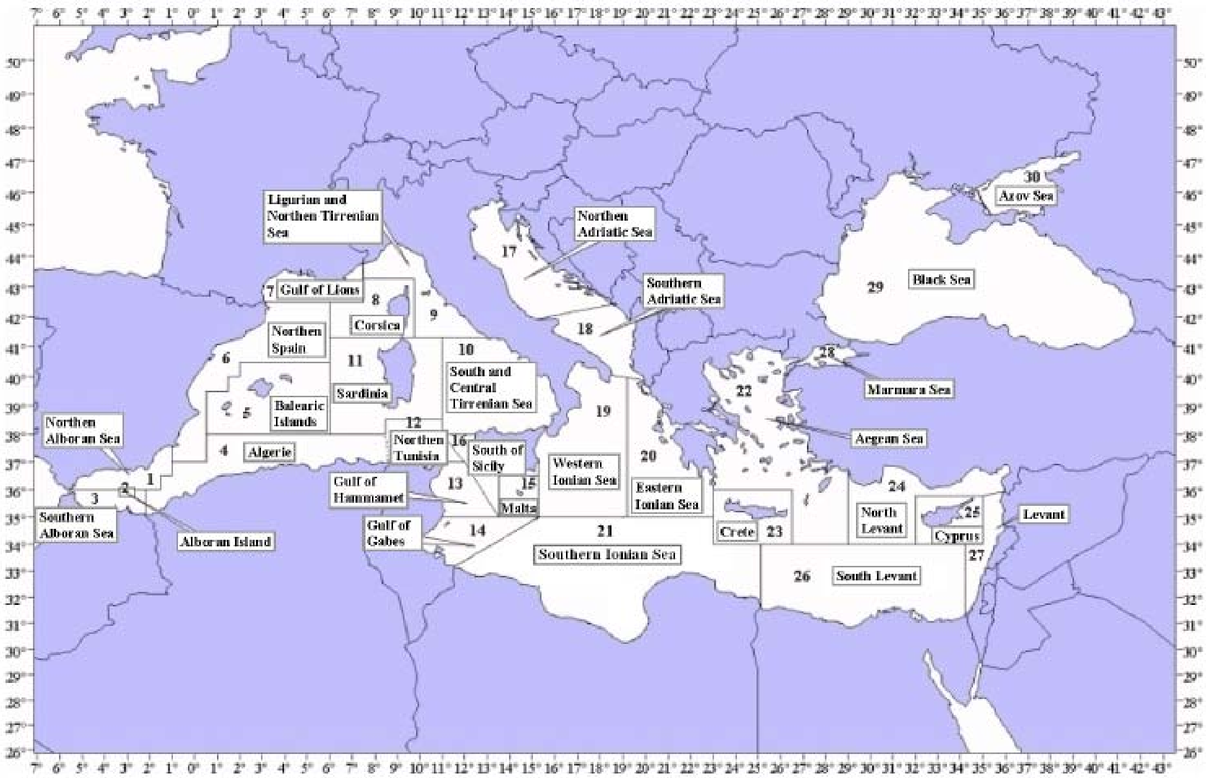
Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	LOA classes					
Activity	Gear classes	Gear groups	Gear type	Target assemblage	Mesh size and other selective devices	< 6	6-12	12-18	18-24	24-40	> 40
Fishing activity	Dredges	Dredges	Boat dredge [DRB]	Molluscs	(a)						
	Trawls	Bottom trawls	Bottom otter trawl [OTB]	Demersal species	(a)						
				Deep water species (b)	(a)						
				Mixed demersal species and deep water species (b)	(a)						
			Multi-rig otter trawl [OTT]	Demersal species	(a)						
			Bottom pair trawl [PTB]	Demersal species	(a)						
			Beam trawl [TBB]	Demersal species	(a)						
		Pelagic trawls	Midwater otter trawl [OTM]	Mixed demersal and pelagic species	(a)						
			Pelagic pair trawl [PTM]	Small pelagic fish	(a)						
	Hooks and Lines	Rods and Lines	Hand and Pole lines [LHP] [LHM]	Finfish	(a)						
				Cephalopods	(a)						
			Trolling lines [LTL]	Large pelagic fish	(a)						
		Longlines	Drifting longlines [LLD]	Large pelagic fish	(a)						
			Set longlines [LLS]	Demersal fish	(a)						
	Traps	Traps	Pots and Traps [FPO]	Demersal species	(a)						
			Fyke nets [FYK]	Catadromous species	(a)						
				Demersal species	(a)						
			Stationary uncovered pound nets [FPN]	Large pelagic fish	(a)						
	Nets	Nets	Trammel net [GTR]	Demersal species	(a)						
			Set gillnet [GNS]	Small and large pelagic fish	(a)						

				Demersal species	(a)						
			Driftnet [GND]	Small pelagic fish	(a)						
				Demersal fish	(a)						
	Seines	Surrounding nets	Purse seine [PS]	Small pelagic fish	(a)						
				Large pelagic fish	(a)						
			Lampara nets [LA]	Small and large pelagic fish	(a)						
		Seines	Fly shooting seine [SSC]	Demersal species	(a)						
			Anchored seine [SDN]	Demersal species	(a)						
			Pair seine [SPR]	Demersal species	(a)						
			Beach and boat seine [SB] [SV]	Demersal species	(a)						
	Other gear	Other gear	Glass eel fishing	Glass eel	(a)						
	Misc. (Specify)	Misc. (Specify)			(a)						
Other activity than fishing				Other activity than fishing							
Inactive				Inactive							
Recreational fisheries (non registered vessels or no vessels)				To be specified	Not applicable	All vessel classes (if any) combined					

(a) Not spelled out in DCR but defined with reference to relevant EU Regulation(s)

(b) Refering only to red shrimps *Aristaeomorpha foliacea* and *Aristeus antennatus*, species not included in the definition of deep sea species given by Council Regulation (EC) 2347/2002.

10. APPENDIX 4. GFCM GSAs



11. ANNEX-EXPERT DECLARATIONS

Declarations of invited experts are published on the STECF web site on https://stecf.jrc.ec.europa.eu/home together with the final report.

European Commission

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Abstract
SGMED-10-02 was held on 31 May - 4 June 2010 in Heraklion (Greece). The report is a compilation of information on existing fisheries and stock data in order to update the status of the main demersal and small pelagic stocks. The report deals with assessment of historic and recent trends in stock parameters (stock size, recruitment and exploitation) and relevant scientific advice. STECF reviewed the report during its Plenary meeting on 8-12 November 2010.

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EUROPEAN COMMISSION

The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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